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METALLOGENY OF OPHIOLITIC AND OTHER MAFIC-ULTRAMAFIC TERRANES IN ALASKA

By

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CONTENTS

UNIT OF MEASURE ABBREVIATIONS

ft	feet	pct	percent
lb	pounds	ppb	parts per billion
oz	troy ounces	ppm	parts per million
oz/st	troy ounces per short ton	st	short tons

METALLOGENY OF OPHIOLITIC AND OTHER MAFIC-ULTRAMAFIC TERRANES IN ALASKA

By Jeffrey Y. Foley[1]

ABSTRACT

Ophiolitic rocks in Alaska contain a variety of metallic and nonmetallic minerals that are of past and potentially future economic significance. Metallic minerals that are reported, or have been produced from ophiolitic terranes in Alaska, include the precious metals, gold, silver, and platinum-group elements (PGE); ferrous metals, including chromium, manganese, and titanium; and base metals, including cobalt, copper, and nickel. All these and a numerous other metallic minerals, including arsenic, barium, bismuth, cadmium, lead, mercury, molybdenum, niobium (columbium), rare-earth elements, thorium, tin, tungsten, uranium, zinc, and zirconium are variably present in placers and lode occurrences and deposits in geologic terranes that contain ophiolites and mafic and ultramafic rocks that are of uncertain relationship to the ophiolites. Nonmetallic minerals including asbestos, jade, and soapstone (massive talc) are variably present in serpentinized ultramafic portions of the ophiolites.

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INTRODUCTION

This report was compiled in collaboration with W.W. Patton, Jr., J.M. Murphy, S.E. Box, and S.W. Nelson, all of the Geological Survey, and L.E. Burns, Alaska Division of Geological and Geophysical Surveys. The USGS Open-File Report authored by these workers and entitled Ophiolitic Terranes of Alaska provides a geologic framework for the metallogenic data and the geologic map contained in that report has been adopted as the base map for this report.

Mineral data contained in this report were largely generated during site-specific investigations that were conducted as part of the U.S. Bureau of Mines Strategic and Critical (S&C) Minerals studies in Alaska. These studies began in 1981 and were conducted by the Bureau's Alaska Field Operations Center (AFOC), with analytical, mineral characterization, benefeciation, and mineral processing support by the Bureau's Research Centers in Albany, (OR), Salt Lake City, (UT), and Reno, (NV). The S&C studies initially concentrated on chromium and platinum-group elements (PGE) and were focused on mafic and ultramafic rocks, including those in ophiolite complexes. Additional mineral data were generated during Bureau of Mines Mineral Land Assessment (MLA) studies, which, are area-wide studies that have focused on specific mining districts and various federally-owned lands in Alaska.

In addition to data generated during the Bureau studies, reports by other agencies and individuals that pertain to the mineral occurrences and deposits described in this report are cited in the list of references at the end of this report. Typically a brief synopsis of the published information is contained in the individual site descriptions. The interested reader is encouraged to refer to the cited references for more detailed and more complete historical and geologic information.

Based on regional, geologic, and tectonic setting, the authors of the companion report have divided ophiolitic terranes in Alaska into five major groups; these are: (1) the northern and western

Alaska (**onw** on figures 1 in this and the companion report), (2) the east-central Alaska (**oec**), (3) the southwestern Alaska (**osw**), (4) the south-central Alaska (**osc**), and (5) the Gulf of Alaska (**oga**) ophiolitic terranes. The companion report also describes two groups of intrusive mafic and ultramafic rocks of uncertain, but possible, ophiolitic affinity (**mum**). The latter two groups occur in distinct regions or belts, (1) between the Yukon River and Fairbanks, and (2) along the Denali-Farewll-Togiak fault system in the Alaska Range.

The companion report provides a provisional definition of ophiolites that addresses the importance of understanding ophiolites in Alaska and appropriately addresses the conflicts that have arisen over the evolving definition and various connotations of the term. As stated by the authors of the companion report and as used in the present report,

> "*ophiolite*...refers to an association of mafic and ultramafic rocks that in a complete sequence is characterized, from bottom to top, by tectonized ultramafic rock, a transition zone of interlayered ultramafic and mafic cumulates, layered gabbro, massive gabbro, a mafic sheeted dike complex, and pillow basalt. Most workers now regard ophiolite assemblages as fragments of ancient oceanic crust and upper mantle that formed along ocean ridges, in small spreading basins, or as basement to island arcs. None of the ophiolites sequences in Alaska is complete and typically one or more of the characteristic components are missing. For this reason we have arbitrarily established the requirement that in order to be labelled an ophiolite the exposed section must include at least one mafic and one ultramafic component. A further requirement is that the mafic-ultramafic assemblages must be allochthonous with respect to the rocks that adjoin them."

In this report, sites are variously described as mineral occurrences or mineral deposits. As used in this report, mineral occurrences refer to sites where minerals containing a given commodity simply have been identified. Mineral deposits refer to sites where valuable minerals are concentrated to the extent that they may invite development for extraction and recovery of the commodity.

METALLOGENIC PROVINCES

Based on the distribution of mineral occurrences and deposits associated with ophiolites and the other mafic and ultramafic complexes described in this report series, eleven metallogenic provinces are delineated on figure 1. The metallogenic provinces, as they relate to the regions containing ophiolites, are:

Northern and western Alaska

Western Brooks Range metallogenic province (**onw**, on fig.1)

Seward Peninsula and western Yukon-Koyukuk Basin margin metallogenic province (**onw**)

Northern Yukon-Koyukuk Basin margin metallogenic province (**onw**)

Southeastern Yukon-Koyukuk Basin margin and Ruby Geanticline metallogenic province (**onw**)

East-Central Alaska

Livengood-Tofty metallogenic province (**mum**)

Salcha-Seventymile River metallogenic province (**oec**)

Alaska Range

Eastern Alaska Range metallogenic province (**mum**)

Central Alaska Range metallogenic province (**mum**)

Southwestern Alaska

Southwestern Alaska metallogenic province (**osw**)

South-Central Alaska

Chugach-Kodiak metallogenic province (**osc**)

Gulf of Alaska metallogenic province (**oga**)

Northern and western Alaska

The northern and western Alaska region contains four metallogenic provinces that are associated with ophiolitic rocks in the western Brooks Range or are marginal to the Cretaceous Yukon-Koyukuk Basin.

Western Brooks Range metallogenic province

Mineral deposits and occurrences of chromium, copper, nickel, and PGE are reported in cumulate mafic and ultramafic rocks of the western Brooks Range ophiolite (map nos. 1-6, fig. 1). Based on surface measurements, mineral characterization tests, and beneficiation studies by the Bureau, the western Brooks Range ophiolite belt is estimated to contain between 800,000 and 2.5 million st chromic oxide (Cr_2O_3) in 70 deposits of high chromium and high-iron chromite at Iyikrok Mountain (map no. 1), Avan Hills (map no. 4), and Misheguk Mountain (map no. 5). Platinum-group elements are associated with chromitites in dunite and peridotite and with iron- and iron-copper-nickel-sulfide minerals in gabbros and troctolites. Chromite, PGE, and gold have been identified in extensive alluvial deposits eroded from the western Brooks Range ophiolite complexes. More recent cooperative studies by the Bureau and the Geological Survey indicate that chromite deposits of similar size and character as those at the other three locations, as well as anomolous gold, silver, PGE, and barium are also present at Siniktanneyak Mountain (map no. 6). High concentrations of gold and PGE are also reported in sulfide-bearing gabbro at Rabbit Creek (map no. 2), located west of the Noatak River. Two unmeasured chromite occurrences are present at Asik Mountain (map no. 3) in the southern part of the province.

Seward Peninsula and western Yukon-Koyukuk Basin margin metallogenic province

Platinum-group elements occurring as native platinum, iron-platinum alloy, and osmiridium are present in gold placers at Granite Mountain (map no. 8) and Dime Creek (map no. 9) on the eastern Seward Peninsula, at the western margin of the Yukon-Koyukuk Basin. Small ophiolite bodies in the area or the Granite Mountain intrusive complex, which also contains ultramafic rock, may be the source of the PGE. Chromite, magnetite, rutile, and ilmenite are particularly abundant in placer concentrates at these locations.

Along the Bluestone River and its tributaries, Alder Creek and Gold Run Creek (map no. 7), and outside the metallogenic province delineated on figure 1, minor platinum is reported in placer gold concentrates. Traces of palladium and platinum are detected in numerous small greenstone stocks in this area.

Northern Yukon-Koyukuk Basin margin metallogenic province

This province (map nos. 10-17 and 19-21) is the source of most of the jade and asbestos produced in Alaska. Placer gold was produced from 1898 until as recently as 1968 in the Dahl Creek (map no. 15) area where chromite is reported in placer concentrates. Chromite is reported in dunite and minor amounts of PGE are reported in pyroxenite, peridotite, dunite, and gabbro samples from the Christian complex (map no. 20). Manganese minerals are reported in mafic volcanic rocks at an unnamed site (map no. 19). Gold and manganese are also reported in sedimentary rocks near Lois Dome (map no. 21). Additionally, there are reports of copper, nickel, and silver in the province. To the south of the delineated province, and in the north-central Yukon-Koyukuk Basin, platinum and cassiterite are reported in placer gold concentrates at Bear Creek (map no. 18).

Southeastern Yukon-Koyukuk Basin margin and Ruby Geanticline metallogenic province

This province (map nos. 22-36) contains between 34,000 and 68,000 st Cr_2O_3 in 13 exposed podiform chromite deposits and chromite lenses in the Caribou Mountain, Kanuti River, Holonada Creek, and Kaiyuh Hills ophiolite masses. Platinum-group elements are detected in placer samples from the Yuki River Valley (map no. 29), which drains the Kaiyuh Hills, and minor platinum was recovered as a byproduct during placer gold mining on Granite Creek (map no. 28), 35 miles east of the Yuki River. Minor chromite is reported in dunite at Mount Hurst (map no. 31), and gold and PGE have been produced from placers on Boob Creek (map no. 30) and other creeks in the area that drain the Mount Hurst ophiolite mass.

Manganese occurrences and deposits of several types are present within this province. In the Ray Mountains (map no. 32), a manganese lense crops out in chert horizons within an andesite sequence. An unmapped ultramafic mass of possible ophiolitic affinity and containing mostly peridotite underlies the area immediately to the east of this occurrence. Epithermal manganese occurrences are present at several sites in the province, including the Avnet (Map no. 33) and Baldry Mountain (map no. 34) prospects and on Little Minook Creek (map no. 35).

Also present in the Province are asbestos, copper, and cobalt occurrences. Gold and cassiterite from unknown sources are present in placer concentrates throughout the province.

East-Central Alaska

Livengood-Tofty metallogenic province

Chromium, nickel, and PGE have been geochemically detected in all the ultramafic bodies (**mum**) along the Livengood-Beaver Creek serpentinite belt (map nos. 37-43). Asbestos, accessory chromite, and clots of massive chromite are locally present, as are iron-nickel sulfide minerals. Platinum-group elements are present in placer gold concentrates and in gold bullion from a lode gold prospect in the Livengood area (map no. 41). Other minerals reported in placer concentrates include silver, mercury, scheelite, and cassiterite. Placer gold production in the Tolovana Mining District, which came primarily from the Livengood vicinity, totals over 400,000 oz.

Near Tofty (map no. 43), chromite that is apparently derived from the American Creek serpentinite body is present in placer gold-cassiterite concentrates from many of the creeks in the area. Placer production for the area, which is in the Rampart Mining District, includes over 450,000 oz Au and 402,000 lb Sn. Other minerals in the Tofty placers include barite, columbite, monazite, xenotime, and zircon. Identified niobium (columbium) resources in the Tofty area include 340,000 lb Nb in dolomitic marble regolith and 100,000 lb Nb_2O_5 in placers.

Placer gold operations on Little Minook Creek (map no. 35) produced over 65,000 oz Au. Placer concentrates there contain argentite, chromite, cinnabar (?), native copper, barite, galena, ilmenite, scheelite, tetradymite, and zircon. Manganese minerals are reported in outcrop on Little Minook Creek and there are several lode manganese occurrences in the hills to the west (map nos. 32-34).

Salcha-Seventymile River metallogenic province

Variably serpentinized and silica-carbonate-altered ultramafic rocks of several types, including allochthonous (oec) masses are present along the Seventymile and Salcha Rivers (map nos. 44-57) and elsewhere in the Eagle Quadrangle. In addition to these are small lenses and sills of intrusive clinopyroxene- and hornblende-rich rocks of uncertain origin. Gold and PGE minerals have been identified in the latter and copper, nickel, gold and PGE have been detected geochemically in silica-carbonate-altered mafic and ultramafic rocks in the Salcha-Seventymile belt. Platinum-group elements, occurring as natural alloys and native metal, plus chromite, silver, tin, and tungsten minerals are locally present in gold placers.

Sixty million short tons averaging greater than 5 pct asbestos are delineated in three deposits in serpentinized ophiolitic rocks by diamond drilling in the Slate Creek area (map no. 54). Several other asbestos deposits in the area have not yet been delineated by drilling.

Alaska Range

Eastern Alaska Range metallogenic province

Chromite- bearing serpentinized peridotite and serpentinite underly several areas in the easten part of this metallogenic province. These sites include Mirror Lake (map no. 58), Carden Hills (map no. 59), and Gillett Pass (map no. 66). Platinum-group elements are detected in chromitite samples from the Carden Hills and sulfide-bearing mafic-ultramafic rocks near VABM Mineral (map no. 61). Asbestos and jade are locally present in this province.

Platinum is reported in heavy mineral and placer concentrates from numerous sites throughout this province including Platinum Creek (map no. 60) and several placer gold-producing areas in the Chistochina Mining District. Over 178,000 oz Au and minor amounts of PGE were produced in this district, most of it from the Slate Creek area (map no. 70).

The Slate Creek area is at the eastern end of an arcuate belt of fault-bounded intrusive igneous rocks (**mum**) that extends for at least 120 miles to the southwest (map nos. 70-81). This belt of igneous rocks parallels the Denali-Farewell-Togiak fault system and other faults, including the Broxson Gulch thrust and Talkeetna faults. Associated with these igneous rocks that range in composition from cumulate dunite and peridotite through gabbro and hypabyssal syenodiorite to silcified and carbonate-altered equivalents, are numerous lode copper-cobalt-gold-nickel-PGE occurrences. Locally associated with these are appreciable chromium, silver, and mercury. Within this belt, the valuable metals occur in a variety of petrologic and mineralogic associations in the fault-bounded intrusive igneous rocks..

Central Alaska Range metallogenic province

Farther to the west, in intrusive ultramafic rocks (**mum**) in the Yentna-Chulitna mineral belt are small banded and podiform chromite deposits, and cobalt, copper, gold, nickel, silver, and titanium lode occurrences (map nos. 82-92). Ultramafic rocks, including dunite and peridotite are locally replaced by silica and carbonate minerals. Also in this region are composite Cretaceous plutons comprising various combinations of peridotite, lamprophyric and alkaline mafic and ultramafic rocks, monzonite, syenite, quartz syenite, and granitic rocks. Pan concentrate samples collected in the vicinity of the composite plutons and placer gold concentrates produced downstream from them and the other dunite-peridotite bodies described in this section contain and have been the source of platinum since the early 1900's. Lode copper-iron-nickel sulfide occurrences are reported in the mafic and ultramafic igneous rocks and in volcanic rocks at several sites in the province. This province overlaps the Alaska Range tin granite belt (Chulitna tin belt ?) and cassiterite is widespread in placer deposits.

Southwestern Alaska metallogenic province

In Southwestern Alaska (map no. 94-103), about 650,000 oz PGE and about 10,000 oz Au were produced from the Salmon River placers, which, eroded from the Goodnews Bay Ural-Alaskan-type ultramafic complex (map no. 101). The Goodnews Bay complex contains minor chromite and copper- and nickel-sulfide minerals. Offshore marine placers and beach placers, on the west side of the Goodnews Bay complex, contain gold, PGE, and chromite. Ophiolitic mafic and ultramafic rocks (osw) in the Cape Newenham-Chagvan Mountain area (map no. 102), and in the Arolik River area (map no. 97 and 98) contain gold, chromium, PGE, copper, and nickel occurrences. Minor amounts of PGE have been identified in heavy mineral concentrates or recovered from gold placers in the Cape Newenham and Arolik River areas. Cross-fiber chrysotile asbestos occurs in serpentinized peridotites near Cape Newenham. Platinum is also reported in placer gold concentrates from Disappointment, Willow, and Wilson Creeks (map no. 93), in the Yukon River Valley and to the north west of the metallogenic province. To the east of the province, and buried beneath unconsolidated sediments and glacial till is the Kemuk Mountain Ural-Alaskan type complex (map No. 104), which, hosts a titaniferous magnetite deposit.

South-Central Alaska

Chugach-Kodiak metallogenic province

Within this metallogenic province (map nos. 105-129), chromite deposits in dunitic portions of ophiolites (**osc**) at Bernard Mountain (map no. 123), and Sheep Hill (map no. 124), Eklutna (map no. 116), Red Mountain (map no. 114), Windy River (map no. 115), and Claim Point (map no. 112), and near Halibut Bay (map no. 105) contain a minimum of 2.8 million st Cr_2O_3. Minor chromite was produced from deposits at Claim Point during the first World War and at Red Mountain during the second World War and the Korean conflict. Additional unmeasured deposits of high-chromium and high-iron chromite have been identified at all theses sites plus Dust Mountain (map 125), the Wolverine complex (map no. 118), and at the other sites on Kodiak Island (map nos. 108-111). Associated with some of the chromite deposits are PGE and minor gold. Other deposits and occurrences in this belt contain cobalt, copper, gold, nickel, silver, manganese, and soapstone.

Gulf of Alaska metallogenic province

Numerous copper prospects were developed in small ophiolite masses (**oga**) (Nelson and others, 1987, and Nelson and Koski, 1987), however, the largest producing mines are hosted in turbidite sequences spatially related to the ophiolites. Lode gold in this metallogenic province was primarily recovered as a byproduct during copper production from the larger mines. Manganese deposits associated with pillow basalts and altered volcanic rocks have been described on Chenega and Hinchenbrook Islands, in Prince William Sound (map nos. 130-137)(Kurtak, 1982, and Goodfellow and others, 1984). Lode gold and copper deposits with associated lead, nickel, silver, tungsten, zinc, and cadmium have been mined and prospected by open-pit and underground workings (Jansons and others, 1984).

EXPLANATION OF TABLE 1 AND FIGURE 1

Information listed in table 1 includes map numbers that correspond to numbered locations on the map shown in figure 1, summaries of available published and unpublished information regarding the metallogeny, geology, mineralogy, geochemistry, and history of each site or area, and citations of published and unpublished references. Commodities of past or potential future economic interest are also listed. Commodities for which evidence supports a genetic association with ophiolitic or mafic and ultramafic rocks of uncertain affinity are listed first. Commodities that are not considered to be of ophiolitic origin or are not generally associated with mafic and ultramafic rocks are listed in parentheses.

LEGEND

Barbs on polygons indicate presence of indicated commodities at specified locations, which, are described in Table 1. In congested areas, some locations are shown by solid circles and the appropriate polygons are connected to those locations by leaders. This symbology refers only to mineral commodities that are clearly associated with or derived from ophiolitic rocks or mafic and ultramafic rocks of uncertain affinity. Commodities not clearly associated with or derived from ophiolitic or other mafic and ultramafic rocks are contained in parentheses, under the heading "commodities" in table 1.

Location described in table 1. Unless indicated by other symbols, no commodity is clearly associated with ophiolitic rocks or other mafic and ultramafic rocks.

Asbestos

Jade

Soapstone

Cr Cr Cr Cr Cu Cu Cu Co Co Co Au Au

Ag **Ag** **Ag** **Mn** **Mn** **Mn** **PGE** **PGE** **PGE** **Ti** **Ti**

Ni **Ni** **Ni** **Hg** **Hg** **Hg**

Base map adapted from Ophiolitic Terranes in Alaska, U.S. Geological Survey Open-File Report ______, by W.W. Patton, Jr., J.M. Murphy, L.E. Burns, S.E. Box, and S.W. Nelson.

Table 1. - Mineral Deposits and Occurrences Associated with Ophiolitic Terranes in Alaska

Northern and western Alaska - Western Brooks Range metallogenic province

No.	Location,	Commodities:
1.	**Iyikrok Mountain**	**Cr:**

Based on surficial measurements, 144,000-383,000 st Cr_2O_3 are present in 2 low-grade deposits with about 4 pct chromite in dismembered ophiolite mass comprising variably serpentinized dunite with associated peridotite, pyroxenite, and gabbro. Twenty other unmeasured lode occurrences and minor placer potential.

References: Patton and others, 1977 and 1989, Roeder and Mull, 1978, Mayfield and others, 1983b, and Foley and others, 1985 and 1986.

2.	**Rabbit Creek**	**Au, Cu, Ni, PGE:**

Based on fire-assay and optical emission spectrographic analyses, eight sulfide-bearing gabbro and troctolite samples contain up to 240 ppb (0.007 oz/st) Au, 3,000 ppm Cu, 200 ppm Ni, 892 ppb (0.0026 oz/st) Pd, and 1,406 ppb (0.041 oz/st) Pt. Higher PGE values are reported for similar samples from the Avan Hills and Misheguk Mountain samples, but no data are provided for individual samples nor are sample locations provided.

References: Mowatt and Jansons, 1985, and Mowatt, 1989.

3.	**Asik Mountain**	**Cr:**

Two banded chromite occurrences with 1- to 2-inch-wide chromite-rich bands in "dark-colored, basic, igneous rock" (dunite ?) at one site and a similar occurrence one half mile to the southwest on the same ridge.

References: Saunders, 1955, Patton and others, 1977 and 1989, Roeder and Mull, 1978, Mayfield and others, 1983b, Mowatt and Jansons, 1985, and Mowatt, 1989.

4. Avan Hills **Cr, PGE, (Au):**

Based on surficial measurements, 467,000-1,734,000 st Cr_2O_3 are present in 26 deposits in dismembered ophiolite comprising variably serpentinized dunite with associated peridotite (primarily wehrlite with lesser lehrzolite and harzburgite), pyroxenite, and gabbro. At least 50 other unmeasured occurrences with potential for large low-grade placer chromite deposits with byproduct gold and PGE. Depending on grade, which may be up to 10 pct chromite, and actual size, the largest of the chromite deposits may contain more than 1,000,000 st Cr_2O_3. Up to 549 ppb (0.016 oz/st) Pd and 480 ppb (0.014 oz/st) Pt detected by fire-assay, atomic absorption procedures in two chromite samples. Subeconomic PGE concentrations reported in placer samples.

References: Patton and others, 1977 and 1989, Roeder and Mull, 1978, Jansons and Baggs, 1980, Mayfield and others, 1983a and 1983b, Curtis and others, 1984, Foley and others, 1985, 1986, and 1989, Mowatt and Jansons, 1985, and Mowatt, 1989, and unpublished Bureau of Mines data.

5. Misheguk Mountain **Cr, PGE, (Au):**

Based on surficial measurements, 117,000-349,000 st Cr_2O_3 are present in 9 low-grade banded zones in dismembered ophiolite mass comprising variably serpentinized dunite with associated peridotite (primarily wehrlite with lesser lehrzolite and harzburgite), pyroxenite, and gabbro. The largest of the identified chromite deposits contains between 78,000 and 261,000 st Cr_2O_3. At least 30 additional unmeasured chromite occurrences with potential for large low-grade placer chromite deposits with byproduct gold and PGE.

Fire-assay, neutron-activation analyses detected up to 4,700 ppb (0.137 oz/st) Pd, 4,200 ppb (0.122 oz/st) Pt, 140 ppb (0.004 oz/st) Ir, 45 ppb (0.0013 oz/st) Os, 360 ppb (0.0105 oz/st) Rh, 98 ppb (0.0029 oz/st) Ru, and 14 ppb (0.0004 oz/st) Au in iron-rich chromitite samples from a clinopyroxene-rich zone in dunite and peridotite, 137 ppb (0.004 oz/st) Pd and 171 ppb (0.005 oz/st) Pt, in plagioclase peridotite with accessory pyrrhotite, and 22 ppb (0.0006 oz/st) Pd, and 42 ppb (0.0012 oz/st) Pt in dunite. Inductively-coupled plasma, mass spectrometry analyses detected 96 ppb (0.0028 oz/st) Pd, 150 ppb (0.004 oz/st) Pt in wehrlite, 230 ppb (0.007 oz/st) Pd and 150 ppb (0.004 oz/st) Pt in dunite with accessory chromite, 210 ppb (0.006 oz/st) Pd and 130 ppb (0.004 oz/st) Pt in metasomatic gabbro, and 140 ppb (0.004 oz/st) Pd and 82 ppb (0.0024 oz/st) Pt in an altered gabbro, all from Misheguk Mountain.

Ore microscope and scanning-electron microscope examination show that sperrylite ($PtAs_2$) inclusions, up to 10 microns across, are associated with argentite in high-iron chromian spinel segregations in clinopyroxene-rich portions of the Misheguk Mountain ophiolite mass. Based on X-ray microanalyses, chromium to iron (Cr:Fe) ratios of this chromian spinel are about 1.3, much lower than the Cr:Fe ratios of more typical chromites in the western Brooks Range ophiolite which are not associated with clinopyroxene-rich rocks.

References: Patton and others, 1977 and 1989, Degenhart and others, 1978, Roeder and Mull, 1978, Jansons and Baggs, 1980, Mayfield and others, 1983b, Curtis and others, 1984, Ellersieck and others, 1984, Foley and others, 1985, 1986, and 1989, Harris, 1987, 1988, and 1989, Mowatt and Jansons, 1985, and Mowatt, 1989, and unpublished Bureau of Mines data.

6. Siniktanneyak Mountain **Ag, Au, Cr, Cu, Ni, PGE:**

Widespread accessory disseminated and banded chromite in serpentinite and dunite with associated pyroxenite, olivine pyroxenite, peridotite (primarily wehrlite with lesser lehrzolite and harzburgite), cumulate gabbro, and hornblende pyroxene gabbro. Several large low grade chromite concentrations similar to those at the other western Brooks Range ophiolite masses and containing from 3-5 pct chromite with numerous smaller concentrations containing from 10-15 pct chromite were identified in

1991. Samples from high grade chromite segregations within these zones contained up to 28 pct Cr. A copper prospect, for which no description is available, was located in the 1970's.

Based on Fire-assay, directly-coupled plasma analyses for gold, palladium, and platinum and inductively-coupled plasma analyses for silver, copper, and nickel, the following anomalous metal concentrations were detected. Samples of very coarse-grained chromite associated with pegmatitic clinopyroxene veins in dunite and lehrzolite contain up to 110 ppb (0.0032 oz/st) Pd and 618 ppb (0.0180 oz/st) Pt. Samples from several sulfide-bearing zones in gabbro contained up to 1,928 ppm Cu and 1,725 ppm Ni. A pyritic diorite dike sample contained 166 ppb (0.0048 oz/st) Pd and 56 ppb (0.0016 oz/st) Pt. A pyritic felsite, collected up slope and along strike with the previous sample contained 13.4 ppm (0.39 oz/st) Ag and 77 ppb (0.0022 oz/st) Au. A Rhyolite(?) sample from a basaltic outcrop at the faulted margin of the complex contained 280 ppb (0.0082 oz/st) Pd and 65 ppb (0.0019 oz/st) Pt. A gabbro sample contained 184 ppb (0.0054 oz/st) Au. Fire-assay, emission spectrography analyses of a clinopyroxenite sample collected near the previous sample location detected 100 ppb (0.0029 oz/st) Pd and 70 ppb (0.0020 oz/st) Pt. Emission Spectrogaphic analyses of a sample from the argentiferous felsite, described above, detected 3,000 ppm Ba.

References: Patton and others, 1977 and 1989, Janson and Baggs, 1980, AEIDC, 1982, Nelson and Nelson, 1982, Foley and others, 1985 and 1986, and unpublished Bureau of Mines data..

Northern and western Alaska - Seward Peninsula and western Yukon-Koyukuk Basin margin metallogenic province

7. Gold Run PGE, (Au):

Minor platinum reported in placer gold concentrates may be derived from widespread gabbro bodies in the surrounding area.

References: Sainsbury and others, 1969, p. 15.

8. Granite Mountain Cr, PGE, (Ag,

Au, Bi, Cu, Mo, Pb, U, Zn):

Gold and minor amounts of platinum were recovered during placer mining on creeks draining Middle Jurassic to Early Cretaceous andesitic volcanic and volcaniclastic rocks where they are intruded by the Cretaceous alkaline to subalkaline Granite Mountain igneous complex. The Granite Mountain complex comprises a hornblende-pyroxene syenite core surrounded by quartz monzonite, monzonite with a border of pseudoleucite syenite, biotite pyroxenite, and various types of garnet-bearing nepheline syenite. Unpublished aeromagnetic data indicate that an intrusive ultramafic complex, much larger than the exposed 30-square-mile Granite Mountain complex, lies beneath the surface (personal communication, Mark M. McDermott, formerly with Anaconda Minerals Company, Anchorage, Alaska). Gold and PGE-bearing streams in the area include Bear Creek (Bear Gulch), Sweepstakes Creek, Peace River, their tributaries, and Quartz Creek.

Bedrock metallic mineral occurrences in the Granite Mountain area include bismuth, copper, gold, lead, molybdenum, silver, zinc, and uranium showings in altered rhyolite, quartz monzonite, syenite, and andesite. Ten or more small open cuts exist on the north side of Split Creek, a tributary of Bear Creek, where chalcopyrite and copper carbonate are reported. Bismuth, molybdenum, and silver are reported in altered syenite and quartz veins in the upper Peace River where anomalous lead, zinc, copper, and uranium have been reported in panned concentrates. Numerous occurrences of argentiferous galena and sphalerite, with associated pyrite and arsenopyrite, are reported in altered andesitic rocks in the Quartz Creek and Kiwalik River areas, west of Granite Mountain.

Mining activity in the area includes sporadic placer gold, with byproduct platinum production, since the early 1900's and as recently as 1986. Based on scanning-electron microscope analysis, the composition of 40 platinum-iron alloy grains picked from a placer sample from Quartz Creek in 1984 averaged 80 pct platinum and 20 pct iron. A minus 20-mesh concentrate produced from a 125-cubic-yard sample collected on Sweepstakes Creek contained 49.6 oz/st Pt and 0.350 oz/st Pd.

Other heavy minerals reported in the placer concentrates include magnetite, ilmenite, hematite, pyrite, olivine, chromite, rutile, zircon, uranothorianite, and garnet.

References: Harrington, 1919b, Gault and others, 1953, p. 4, Miller and Elliott, 1969, Miller, 1970 and 1972, Cobb, 1973, p. 62 and 73, Cobb, 1975, Foley and others, 1989, and unpublished Bureau of Mines data.

9. Dime Creek **PGE, (Au, Ti)**

Gold, minor amounts of platinum, and lesser osmiridium were recovered during placer mining on Dime Creek, which, drains Middle Jurassic to Early Cretaceous andesitic volcanic and volcaniclastic rocks with associated diabases and peridotites. PGE and chromite were possibly derived from peridotite body at head of Dime Creek. Aeromagnetic data indicate that an elongate, north-south-trending ultramafic body underlies much of Dime Creek and the Sweepstakes Creek area, a few miles to the north (personal communication, Mark M. McDermott, formerly with Anaconda Minerals Company, Anchorage, Alaska).

Other heavy minerals reported in the placer concentrates include olivine, pyroxene, magnetite, hematite, limonite, chromite, rutile and garnet.

Gold was discovered in 1915. About 35 oz platinum was recovered in 1917. The platinum to gold ratios in placer concentrates range from about 1 oz platinum per 250 oz gold on lower Dime Creek to 1 oz platinum per 100 oz gold on the upper reaches of the creek. Platinum from upper Dime Creek includes angular and shot-like grains.

References: Harrington, 1919b, Cobb, 1973, p. 60 and 82, Cobb, 1975, and Foley and others, 1989.

Northern and western Alaska - northern Yukon-Koyukuk Basin margin metallogenic province

10. Hunt River **Asbestos:**

Strong, flexible, amphibole asbestos with fibers up to 2 inches long from a 0.5-inch seam reported by an Eskimo hunter at the extreme head of Hunt River. Location is uncertain.

References: Anderson, 1947.

11. Jade Mountain **Asbestos, jade, Ni:**

Cross- and slip-fiber chrysotile seams up to 0.6 inches wide and averaging 0.25 inch wide exposed in numerous outcrops in 300- by 600-ft area and in a short tunnel at the head of Jade Creek. Cross- and slip-fiber tremolite, low-quality and nephrite, and garnierite are also reported. Gem-quality nephrite reported from nearby Jade Creek.

References: Anderson, 1945 and 1947, and Heide and others, 1949.

12. Shungnak River **Asbestos, jade,**

Cross- and slip-fiber chrysotile and other asbestiform minerals make up several percent of fractured serpentinite bedrock in several hundred-feet-wide by 8-ft-long zone at Bismark Mountain. Asbestos is variably present in larger serpentinite zone that is exposed for over 2 miles. Slip-fiber veins from 0.5 to 2 inches wide with fibers mostly less than one inch long but reaching a maximum length of about two inches. Associated minerals include magnesite, antigorite, magnetite, and nemalite, a fibrous form of brucite. Gem-quality nephrite reported in float from Shungnak River.

Four bulldozer trenches were excavated by the Bureau of Mines in 1944. A 2-st sample from these trenches was shipped to the Bureau's Research Center in Rolla, Missouri for beneficiation tests.

References: Anderson, 1945 and 1947 and Heide and others, 1949.

13. Cosmos Creek **Asbestos, jade:**

Cross-fiber chrysotile veins from 0.25 to 5 inches wide form extensive network in 1,300-ft-long portion of 125-ft-thick serpentinite mass. Associated slip-fiber chrysotile with 2- to 4-inch-long fibers. Nephrite boulders recovered from Cosmos Creek.

Minor development took place prior to 1945. In 1945 and 1946, the Bureau of Mines excavated six bulldozer trenches and collected two large samples for beneficiation and grade testing by Johns-Mansville Company, Asbestos, Quebec.

References: Anderson, 1945 and 1947, and Heide and others, 1949.

14. Wesley **Asbestos, jade:**

Asbestiform tremolite and gem-quality nephrite near the head of Wesley Creek.

References: Anderson, 1945.

15. Dahl Creek **Asbestos, jade, Cr, (Au, Cu):**

Tremolite and high-quality cross- and slip-fiber chrysotile in serpentinized nephritic and peridotite bedrock with tremolite fibers up to 1 and 2 ft long at two locations, with associated nephrite, talc, magnesite, magnetite, and antigorite. Tremolite lenses up to 6 feet thick occur in serpentinized zone up to several hundred feet long. Forty-seven short tons of asbestiform tremolite produced from four trenches and a 228-ft adit in 1944 and 1945 by Arctic Circle Mining Company, Candle, Alaska. One short ton of chrysotile and 5 st of jade boulders produced in 1945. Remaining reserve estimates include at least 45 st of tremolite and several tons of chrysotile Nephrite boulders reported in Dahl Creek.

Deposits discovered in 1932 and 1933. Development by the Arctic Circle Mining Company began in 1943. Additional development work by the Bureau of Mines consisted of cleaning out the earlier workings in 1946 and collection of a 1,090-lb sample for beneficiation tests at the Bureau's Rolla, Missouri Research Center.

Placer gold was discovered on Dahl Creek in 1898 and on nearby streams in the succeeding years. Production continued until as recently as 1968. Chromite is reported in the placer concentrates.

References: Anderson, 1945 and 1947 and Heide and others, 1949, Cobb, 1973, p. 56 and 59.

16. Kogoluktuk River **Asbestos:**

Asbestiform amphibole and cross-fiber chrysotile in placer workings and in float on south side of lower California Creek, tributary to Koguluktuk River. Fibers up to 3 inches long reported.

References: Anderson, 1945 and 1947 and Heide and others, 1949.

17. Herbert, Ivan, and Stewart **Jade:**

Recorded jade production.

References: Unpublished Bureau of Mines data.

18. Bear Creek **PGE, (Au, Sn):**

"Platinum-group metals" and cassiterite identified in placer samples collected in the 1920's. More recently, placer gold was recovered by a dredge operated on Bear Creek.

References: Cobb, 1973, p. 138, and 144-145 and Cobb, 1975.

19. Unnamed **Mn:**

Rhodochrosite, manganite, and pyrolusite are reported in altered mafic volcanic rocks and phyllite.

References: Patton and Miller, 1966.

20. Christian River **Cr, PGE:**

Seven percent chromite was estimated in dunite sample from Levi Creek and 6.6 pct Cr_2O_3 was detected by atomic absorption in dunite sample near Christian River, at head of Timber and Marten Creeks. Fire-assay, atomic absorption analyses detected 20 ppb (0.0006 oz/st) Pd and 103 ppb (0.003 oz/st Pt) in Cr-bearing magnetite from Levi Creek and traces of PGE in pyroxenite, peridotite, dunite, and gabbro from the Christian River complex.

References: Hawley and Garcia, 1976 Enns and Findlay, 1977, Patton and others, 1977 and 1989, and Foley and others, 1989.

21. Lois Dome (Au, Mn):

One-inch-wide psilomelane vein in red ferruginous argillite and gold-bearing manganiferous pebble from the same area. Mineral deposits in the region possibly include sedimentary and volcanic types.
References: Brosge and Reiser, 1968 and Barker, 1981.

Northern and western Alaska - southeastern Yukon-Koyukuk Basin margin metallogenic province

22. Caribou Mountain Cr, PGE:

Based on surficial measurements, 2,000-2,500 st Cr_2O_3 are present in three deposits containing high-chromium chromite and magnesian chromohercynite in banded intervals up to 10 ft thick and exposed for up to 50 ft along strike. Seven additional unmeasured or minor occurrences of banded and disseminated chromian spinel. One high-grade chromite sample contained 377 ppb (0.011 oz/st) Pd and 1,337 ppb (0.039 oz/st Pt).

Ultramafic and mafic rocks at Caribou mountain include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970, Clautice, 1978, Dahlin and others, 1983, Foley and McDermott, 1983, Foley and others, 1985, 1986, and 1989, and Loney and Himmelberg, 1985.

23. Upper Kanuti River **Cr:**

Numerous small occurrences of disseminated and massive chromite in dunite and peridotite bedrock and rubble.

References: Patton and Miller, 1970, Patton and others, 1977 and 1989, Foley and McDermott, 1983, Foley and others, 1985, and Loney and Himmelberg, 1985.

24. Lower Kanuti River **Cr, PGE:**

700-800 st Cr_2O_3 in banded and disseminated high-chromium chromite in 5-ft-thick by 80-ft-long exposure. Thirteen additional unmeasured or minor occurrences. Tabled chromite concentrate from one sample contained 0.010 oz/st Pt.

Ultramafic and mafic rocks at Caribou mountain include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970, Patton and others, 1977 and 1989, Clautice, 1978, Dahlin and others, 1983, Foley and McDermott, 1983, and Foley and others, 1985, 1986, and 1989, and Loney and Himmelberg, 1985.

25. Sithylemenkat Lake **Cr, Co, Cu:**

Accessory chromite in small serpentinized dunite, serpentinized peridotite, and gabbro body. 700 ppm Co, 3,000 ppm Cr, and 500 ppm Cu in frost boil sample containing serpentinite fragments.

References: Herreid, 1969, p. 18-19, Patton and Miller, 1970, Patton and others, 1977 and 1989, Foley and others, 1985, 1986, and 1989, and Loney and Himmelberg, 1985.

26. Kilolitna River **Cr:**

Numerous small occurrences of disseminated and massive high-chromium chromite in dunite bedrock and rubble.

Ultramafic and mafic rocks at Kilolitna River include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970, Patton and others, 1977 and 1989, Foley and others, 1985, and 1989, and Loney and Himmelberg, 1985.

27. Holonada Creek **Cr:**

14,500-27,500 st Cr_2O_3 in a 400-ft-long, 5- to 15-ft-wide deposit with 20 pct high-chromium chromite and four other low-grade deposits with less than 1,000 tons Cr_2O_3 in each.

Ultramafic and mafic rocks at Caribou mountain include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970, Patton and others, 1977 and 1989, Foley and others, 1985 and 1986, Loney and Himmelberg, 1985, and unpublished Bureau of Mines data.

28. Granite Creek **PGE, (Au):**

Minor platinum produced as byproduct during placer gold mining.

References: Cobb, 1973, p. 170.

29. Kaiyuh Hills and Yuki River **Cr, PGE:**

Based on surface measurements, 17,000-37,000 st Cr_2O_3 are estimated in four high-chromium chromite deposits in dunite. The largest deposit contains a 3-ft-wide by 300-ft-long massive chromite layer and the other 3 are low-grade banded and disseminated zones with 5 pct or less chromite. Fourteen additional minor or unmeasured occurrences plus placer potential. PGE detected in placer samples from the Yuki River Valley and potential exists for recoverable PGE in placer deposits (personal communication, Toni Hinderman, Alaska Earth Sciences, Anchorage, Alaska).

Dismembered ophiolite in the Kaiyuh Hills comprises tectonized harzburgite and dunite, cumulate dunite, wehrlite, and olivine clinopyroxenite, and gabbro.

References: Foley and others, 1984, 1985, 1986, and 1989, and Loney and Himmelberg, 1984.

30. Boob Creek **Cr, PGE, (Au):**

Thirty oz PGE produced during placer gold mining in 1917. PGE and chromite eroded from nearby Mount Hurst dunite and peridotite. Iron-platinum alloy containing 90-92 pct Pt, about 5 pct Fe, and up to 2 pct Rh, and osmiridium with minor ruthenium identified by microprobe analysis in placer concentrate from recently excavated prospect pit.

References: Harrington, 1919a, p.349-350, Roberts, 1984b, Foley and others, 1985, and 1989, unpublished Bureau of Mines data.

31. Mount Hurst **Cr, PGE:**

Chromite in seven dunite bedrock and nine dunite float occurrences. Largest bedrock occurrence contains from 35 to 80 pct ferroan picrochromite, is exposed for 26 ft along strike, and ranges from 6 to 32 inches wide. Up to 890 ppb (0.026 oz/st) Pt detected in chromitite sample.

Dismembered ophiolite at Mount Hurst comprises tectonized harzburgite and dunite, cumulate dunite, wehrlite, and olivine clinopyroxenite, and gabbro.

References: Loney and Himmelberg, 1984, Roberts, 1984a and 1984b, and Foley and others, 1985 and 1989.

32. Ray Mountains **Asbestos, Mn:**

Up to 25 pct Mn in samples from 42-inch-thick bed in chert horizon within thicker andesite sequence. Mn-rich cherty interval exposed for 200 ft along strike. Hausmanite and braunite (manganese-oxides) identified by X-ray analyses. Other occurrences in the area consist of manganese-rich float and rubble. Chrysotile fibers in talus on nearby Dreamland Creek.

References: Bureau of Mines, 1963, p. 29 and 44, and Barker, 1980, p. 20.

33. Baldry Mountain **(Mn):**

Psilomelane-bearing manganese deposit, west slope of Baldry Mountain.

References: Killeen and Mertie, 1951, and Burand and Saunders, 1966.

34. Avnet prospect **(Ag, Mn):**

Abundant psilomelane and minor pyrolusite in quartzite and vein quartz float, talus, and rubble scattered over 600-ft by 3,000-ft area along flat-topped ridge. Manganese minerals occur primarily as lattice works and stockworks in hydrothermal vein quartz in quartzite and phyllite country rock. Samples contained from 0.59 to 34.4 pct Mn and up to 0.28 oz/st Ag.

References: Thomas, 1965, and unpublished Bureau of Mines data.

35. Little Minook Creek **Cr, (Ag, Au, Bi, Cu, Hg?, Mn, Pb, W):**

Rhodochrosite or rhodonite reported in outcrop on Little Minook Creek. Diabase dikes cut slate, sandstone and greenstone(?) bedrock, which, is jointed and sheared and contains pyrite, chalcopyrite, and auriferous quartz-calcite veins. Placer concentrates contain gold, chromite, picotite, native copper, native silver, hematite, barite, pyrite, galena, ilmenite, magnetite, argentite, tetradymite, scheelite, cinnabar(?), garnet, zircon, and sphene.

Gold was discovered on Little Minook Creek in 1893 and up until 1977, total production is estimated at 50,000-65,000 oz.

References: Mertie, 1934, p. 181-183, Burand and Saunders, 1966, Cobb, 1973, p. 165-167, and Cobb, 1977, p.55-57.

36. Lost Creek **Asbestos, Mn:**

Cross-fiber chrysotile asbestos "in float rock", manganite disseminated in chert breccia with clay-altered clasts, and botryoidal psilomelane in vein quartz rubble over several hundred-feet-wide area at ridgecrest.

References: Barker, 1980, p. 20.

East-central Alaska - Livengood-Tofty metallogenic province

37. Big Creek **Asbestos:**

Asbestiform amphibole along fractures in serpentinized ultramafic outcrop.

References: Barker, 1980

38. Beaver Creek **Asbestos, Cr, Ni, PGE:**

Up to 0.51 pct Ni and detectable platinum, palladium, and rhodium in serpentinite bedrock samples. PGE reported in Livengood Creek placer concentrates probably derived from these rocks. Thin chrysotile veinlets in serpentinite bedrock and chromite in serpentinite scree.

References: Overbeck, 1918, Foster, 1969, Chapman and others, 1971, and Cathrall and others, 1987.

39. Parker prospect **Ni:**

Nickel distributed among silicates, spinel-group minerals, alloys, and sulfides in serpentinite. Up to 0.4 pct Ni in rock samples.

References: Foster and Chapman, 1967.

40. Griffin prospect **Cr, Ni, (As, Au):**

Up to 3.9 ppm Au, 1 pct As, 5,000 ppm Cr, and 1,000 ppm Ni in sulfide-bearing, green-stained, silica-carbonate-talc-altered serpentinite.

References: Foster and Chapman, 1967, and Foster, 1968a and 1968b.

41. Livengood Creek **Cr, Ni, PGE, (Ag, Au, Hg, Sb, Sn, W):**

Accessory chromite and anomalous nickel concentrations in serpentinite bedrock and abundant chromite in placer gold concentrates from Livengood Creek and nearby streams, all in the Tolovana Mining District. Associated with the sepentinite in the Livengood area are gabbro and diorite dikes and plutons. Gold, silver, arsenic, antimony, and mercury are reported in quartz-calcite veinlets, proximal to small rhyolite bodies, and granitic rocks in the vicinity of upper Ruth, Lillian, and Olive Creeks. Heavy minerals in placer gold concentrates include magnetite, hematite, chromian spinel, cinnabar, stibnite, other sulfide minerals, scheelite, cassiterite, monazite, and a niobium-titanium-uranium- rare earth mineral. PGE have been detected during fire-assay analysis of placer concentrates from Livengood Creek, and in gold bullion from local placer mines and one lode prospect. Traces of platinum and palladium were detected in serpentinite bedrock samples. Lizardite and clinochrysotile, but no asbestiform aggregates of serpentine minerals are reported.

Workable placer gold deposits were discovered in the Livengood Creek area in 1914. Through 1960, at least 380,000 oz of gold had been produced by drifting, dredging, and non-float operations. Most of the production came from the large bench deposit on the northwest side of the Livengood Creek valley. Non-float placer operations continue to operate on Livengood Creek, some of its tributaries, and nearby Olive Creek, a tributary of the Tolovana River.

References: Overbeck, 1918, p. 183-184, Joesting, 1942, p. 17-20, Berg and Cobb, 1967, p. 239-240, and 1973, p. 174-176, Foster and Chapman, 1967, Foster, 1968a, 1968b, and 1969, Cathrall and others, 1987, Loney and Himmelberg, 1988, Foley and others, 1989, Patton and others, 1989, p.12-13, and unpublished Bureau of Mines data.

42. Barrett prospect **(Ag, Au, Co, Cu, Mn, Pb):**

At least six mineralized shear zones in metamorphosed sedimentary rocks near biotite granite contact. Explored by 3 shafts, 1 adit, and 3,200 ft of diamond drilling in 8 holes. Erythrite with galena, chalcopyrite, pyrrhotite, pyrite, siderite, cerussite, limonite, goethite, hematite, quartz, calcite, malachite, and azurite. Gold (0.05-0.1 oz/st) and silver (5-8 oz/st) reported. 3.9 pct Mn in Bureau of Mines sample.

References: Wedow and others, 1952, Wayland, 1961, Maloney, 1971, and Cobb, 1977, p. 43.

43. Tofty **Cr, (Au, Nb, REE, Sn, Ti, Zr):**

Abundant chromite and picotite are reported in placer gold concentrates from American Creek, Colorado Creek, Boulder Creek, Cache Creek, Deep Creek, Sullivan Creek, and Tofty Gulch. Other heavy minerals identified in placer concentrates include abundant cassiterite and lesser amounts of pyrite, magnetite, ilmenite, barite, hematite, zircon, columbite, aeschynite, monazite, and xenotime.

Chromite in the placer concentrates is apparently derived from small, northeast-striking serpentinite bodies along Serpentine Ridge, between Fish Lake and Roughtop Mountain. Antigorite is the primary serpentine mineral, however, asbestiform aggregates are not reported. Unpublished Bureau of Mines data include reports of up to 50 pct chromite in select serpentinite samples. This narrow serpentinite belt lies immediately north of and parallels the Tofty gold-tin placer belt.

Gold was discovered in the Tofty area in the winter of 1906-7 and by 1961, 450,000 fine oz of gold were produced and between 1906 and 1982, placers in the area produced 402,000 lb of tin. Placer gold mining continued intermittently beyond 1961, but, no accurate gold production figures are available for that period. Mining operations included hand-mining, ground sluicing, drift mining, bucket-line dredging, and mechanized non-float operations.

Identified niobium resources in the Tofty area include 340,000 lb in dolomitic marble regolith and 100,000 lb Nb_2O_5 in placers.

References: Mertie, 1934, p. 205-214, Waters, 1934, p. 238-246, Thorne and Wright, 1948, Thomas, 1957, Wayland, 1961, Cobb, 1973, p. 137-142, Cobb, 1977, Southworth, 1984a, Warner, 1985, Warner and others, 1986, and unpublished Bureau of Mines data.

East-Central Alaska - Salcha-Seventymile River metallogenic province

44. Caribou Creek **PGE, (Au, Sn, W):**

Platinum, cassiterite, and scheelite reported in placer gold dredge concentrates. Fire assay analysis by the Bureau of Mines detected 7.1 and 0.1 oz/st Pt in two dredge concentrate samples. Platinum is probably derived from serpentinized ultramafic and associated rocks similar to those in the vicinity of VABM Nail, near the Salcha River. Cassiterite and scheelite are present in many creeks in the region with no known lode deposits.

References: Cobb, 1973, p. 126 and 129, Southworth 1984b and 1985, Foley and others, 1989, and unpublished Bureau of Mines data.

45. Nail Ridge and Salcha River **Cu, Cr, Ni, PGE:**

Traces of platinum in peridotite and serpentinite in the Salcha River region and 0.6 pct Ni and traces of platinum in serpentinite at the head of Nickel Creek. High-Al, high-Mg chromite disseminated throughout serpentinized and carbonate-silica-altered peridotite masses. Pyrrhotite and chalcopyrite occur as accessory minerals and are concentrated in an iron-stained zone where 3.5 oz/st Pd were detected in a rock sample by fire-assay, atomic absorption analyses.

References: Joesting, 1942, p. 17-20, Eberlein and others, 1977, Menzie and Foster, 1978, Weber and others, 1978, Foster and others, 1979, Southworth, 1984b and 1985, Foley and others, 1989, and unpublished Bureau of Mines data.

46. Woodchopper Creek **PGE, (Au, Sn, W):**

Traces of platinum (0.42 pct of analyzed specimen) and iridium ("trace") were reported to be alloyed with placer gold recovered in early placer gold dredging operations. Platinum was claimed as seignorage by the U.S. Mint during refining of the gold recovered in 1938. Subsequent efforts were successful in separating small amounts of platinum prior to refining by the U.S. Mint. Scheelite, wolframite, and cassiterite were identified in Bureau of Mines pan concentrate samples.

Several bedrock sources have been proposed for the placer gold in the region; the platinum and associated PGE are probably derived from the fairly extensive ultramafic rocks at the heads of Woodchopper Creek and other north-flowing tributaries of the Yukon River in the Circle Mining District.

Recorded production for Woodchopper Creek, prior to 1963, is 117,654 oz Au and 9,783 oz Ag. Most of this was produced by a bucket-line dredge that began operating in 1937.

References: Mertie, 1942, p. 257-259, and 1969, p. 90-91, Cobb, 1973, p. 116, 119, and 122, and Cobb, 1975, Barker, 1986, p. 10 and 17, and Foley and others, 1989.

47. Boulder Creek **Cr, PGE, (Au, Ag):**

Gold, "osmiridium" grain, and chromite identified in pan concentrate sample. Scanning-electron microscope analysis of the PGE grain indicate it has an Os:Ir ratio of about 5:1; therefore it corresponds to the composition of iridosmine.

Recorded production includes 334 oz gold and 42 oz Ag recovered prior to 1951. Mining methods incuded open-cut and drift mining. Open-cut operations, but no recorded production, are reported in 1976 and 1977.

References: Cobb, 1973, p. 116 and 120, Barker, 1986, p. 10 and 17, and Foley and others, 1989.

48. Washington Creek **PGE, (Au):**

Platinum-iron alloy grain identified by electron microprobe examination and 103 (0.003 oz/st) Pt detected, by Fire-assay emission spectrography, in pan concentrate sample with visible gold.

References: Mertie, 1942, p. 257-259, and 1969, p. 90, Barker, 1986, p. 17, Foley and others, 1989, and unpublished Bureau of Mines data.

49. Fourth of July Creek **PGE, (Au):**

Traces of platinum (0.28 pct of analyzed specimen), iridium (0.05 pct), and palladium ("trace") were reported to be alloyed with placer gold recovered in early mining operations.

References: Mertie, 1942, p. 257-259, and 1969, p. 90, Cobb, 1973, and 1975, Foley and others, 1989, and Barker, 1986.

50. Seventymile River **PGE, (Au):**

Discrete platinum grains in placer concentrates from Lucky Gulch and platinum (0.20 pct) and iridium (0.02 pct) alloyed with placer gold from Broken Neck Creek. The PGE are probably derived from the widespread ultramafic rocks that occur along a splay of the Tintina fault in the Seventymile River valley.

References: Joesting, 1942, p. 20, Mertie, 1942, p. 257-259, and 1969, p.90, Cobb, 1973, p. 116, 122, and 125, and 1975, Keith and Foster, 1973, Foster and Keith, 1974, and Foley and others, 1989.

51. Eagle Bluff and Greenstone Point **Ag, Au, Co, Cu, Ni, (Pb, Zn):**

Erythrite and annabergite in copper-nickel sulfide veins in greenstone with minor gold values. Traces of gold reported and up to 1.5 ppm (0.04 oz/st) Ag, Au, 2,000 ppm Co, 1 pct Cu, 1,500 ppm Pb, and 1,500 ppm Zn detected by emission spectrography.

References: Wedow, 1954, Bureau of Mines, 1963, Saunders, 1967, and Clark and Foster, 1971, p. 14.

52. Wolf Creek **Cr, (Au):**

Chromite reported in placer gold concentrates.

References: Cobb, 1973, p. 126.

53. Butte Creek **Au, PGE:**

Gold and PGE are concentrated in small biotite clinopyroxenite sills and lenses, with associated felsic dikes and granodiorite near Butte Creek. These metals were recovered in heavy mineral concentrates from alluvium and colluvium in proximity to the igneous bodies. Based on fire-assay, emission spectrography, up to 3 ppm (0.087 oz/st) Pt and 1.5 ppm (0.044 oz/st) Pd, and based on fire-assay, atomic absorption up to 80 ppb (0.002 oz/st) Au and 36 ppb (0.001 oz/st) Rh were detected in biotite clinopyroxenite. Sperrylite and stibiopalladinite were identified by scanning electron microscopic examination of select biotite clinopyroxenite samples. SEM examination also identified sperrylite and platinum-iron alloy in heavy mineral concentrates produced by panning and sluicing alluvium and colluvium from gullies that drain these bodies. Based on fire-assay, inductively-coupled plasma procedures, up to 70.4 ppm (2.054 oz/st) Au, 16.8 ppm (0.49 oz/st) Pd, and 29.3 ppm (0.85 oz/st) Pt were detected in the heavy mineral concentrates.

References: Keith and Foster, 1973, Foster and Keith, 1974, Keith and others, 1987, and unpublished Bureau of Mines data.

54. Slate Creek **Asbestos:**

Sixty million tons averaging greater than 5 pct asbestos delineated by 40,000 ft of diamond-drilling in the Cache Creek, Core Shack Ridge, and Pump Creek deposits. Asbestos at these deposits is mostly cross-fiber chrysotile suitable for use in concrete. Four additional deposits tested by drilling and five others remain untested.

References: Doyon, Ltd., 1986.

55. Alder Creek **Au, Cu:**

Traces of gold detected by inductively-coupled plasma analyses of red-iron-stained and altered, pyrite- and chalcopyrite-bearing, fine-grained basaltic rock from trench in exposed dike, west of Alder Creek. Dikes crop out intermittently for several miles to the northwest, and appear to be faulted to the south along northeast-flowing tributaries of the Seventymile River (e.g. Flume Creek). Reports indicate that these dikes have been investigated as lode-gold sources by diamond-drilling within the last two years. **References:** Unpublished Bureau of mines data.

56. Flume Creek **Au, Co, Cr, Ni:**

At lower Flume Creek, a 40-ft-wide mass of gold-, pyrite-, and arsenopyrite-bearing quartz-carbonate rock and associated altered diorite (rodingite?) that contains hydrogrossularite, diopside, chlorite, and prehnite cut serpentinite bedrock. Pyrite- and chalcopyrite-bearing, basaltic dikes border these altered zones on the south. Emission spectrographic analyses indicate 1,700-6,400 ppm As, up to 400 ppb (0.012 oz/st) Au, 300 ppm Co, over 5,000 ppm Cr, and over 5,000 ppm Ni in rock samples from lower Flume Creek. Fire-assay, inductively-coupled plasma analyses detected 340 ppb (0.01 oz/st) Au and 970 ppm Ni in a pan concentrate sample from upper Flume Creek and up to 1,370 ppb (0.04 oz/st) Au in altered diorite and other lithologies from the altered zone on lower Flume Creek. A short adit was driven into the altered bedrock and minor placer gold production took place on lower Flume Creek. Accessory chromite in serpentinized peridotite are present on upper Flume Ck.

References: Clark and Foster, 1971, Keith and Foster, 1973, Foster and Keith, 1974, Foley and others, 1985 and 1989, and unpublished Bureau of Mines data.

57. Mount Sorenson **Asbestos, Co, Cr, Ni, PGE:**

Minor asbestiform minerals, including lizardite and chrysotile (clinochrysotile?), accessory chromite, and traces of PGE (10 ppb Pt) in serpentinized peridotite. Emission spectrographic analyses indicate up to 300 ppm Co, over 5,000 ppm Cr, and 5,000 ppm Ni in rock samples. Ultramafic rocks include massive serpentinized harzburgite and dunite with minor cross-cutting veinlets of the asbestiform minerals and some slip-fiber asbestos on massive blocks. Alteration minerals also include actinolite (tremolite), talc, brucite, magnetite, and chlorite (penninite). Diabase is reported to occur as tectonic inclusions, and bastite has formed as a result of serpentinization. Quartz-carbonate (magnesite) veins cut altered ultramafic rock.

References: Keith and Foster, 1973, and Foster and Keith, 1974.

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58. Mirror Lake Creek **Cr:**

Cobble-size massive chromite float derived from serpentinized peridotite mass.

References: Richter and others, 1975.

59. Carden Hills **Cr, PGE:**

Accessory to 6 pct coarse-grained, disseminated, slightly magnetic chromite in dunite layers that are interlayered with gabbro and pyroxenite. The largest exposed chromite-bearing area is from tens to hundreds of feet wide and thousands of feet long. Three chromite-bearing dunite samples contained from 0.002 to 0.02 oz/st combined Pt (50-300 ppb) and Pd (23-44 ppb) with traces of Ir, Rh, and Ru as determined by fire-assay, inductively-coupled plasma methods.

References: Richter and others, 1975, Foley and others, 1985 and 1989, and unpublished Bureau of Mines data.

60. Platinum Creek **PGE:**

Small amounts of platinum reported from Platinum Creek.

References: Rose, 1965, p. 41, Richter and others, 1975, and Foley and others, 1989.

61. Mineral **PGE:**

Minor platinum and palladium detected by fire-assay, atomic absorption analyses in twenty rock samples from fault-bounded, serpentinized, and silica-carbonate-altered pyroxenite, peridotite, and dunite. Maximum combined detected PGE is 0.006 oz/st (125 ppb each, Pd and Pt).

References: Foley and others, 1989, and unpublished Bureau of Mines data.

62. Mentasta Pass Lodge **Ag, Au, Cu:**

Bornite and trace chalcopyrite as vesicle fillings and as irregular segregations in a 400-ft-thick section of the upper Slana basalt, 0.7 miles southeast of the Mentasta Pass Lodge. Analysis of a grab sample by atomic absorption yielded 1.1 pct Cu with traces of gold and silver.

References: Richter, 1967, p. 18.

63. Discovery **Jade:**

Minor nephrite production reported.

References: Unpublished Bureau of Mines data.

64. Mentasta Pass **Jade:**

Nephrite discovered in prospect pit in serpentinite near junction of Mentasta Village Road and Tok Highway.

References: Richter, 1967, p. 18, and Richter and others, 1975.

65. Alteration Creek **Ag, Au, Cu:**

Chalcopyrite and copper oxide minerals in limonite- and silica-bearing quartz veins in diorite and altered volcanic rocks of the Slana basalt. Based on atomic absorption analyses, one sample contained 1.5 pct Cu with minor silver (0.54 oz/st) and a trace of gold (0.02 oz/st).

References: Richter, 1967, p. 16-17.

66. Gillett Pass **Asbestos, Cr:**

Accessory chromite in 2-mile-long dunite body and acicular and fibrous antigorite in carbonate-altered portions of dunite mass.

References: Richter, 1967, p. 12 and 18.

67. Slana River **Ag, Au, Cu, Ni:**

A piece of massive chalcocite found in Slana basalt and limestone talus east of the Slana River and a band or pod of pyrrhotite with minor chalcopyrite in Slana basalt, across Slana River, 3 miles to northwest. Based on atomic absorption analyses, pyrrhotite-rich grab sample contained 0.6 pct Cu and 0.04 pct Ni with traces of gold and silver.

References: Richter, 1967, p. 18.

68. Eagle Creek **Au, Cu, PGE**

Platinum and native copper were reported in placer gold concentrates in 1941 and 1942. Other heavy minerals in the concentrates include magnetite and barite. Rock fragments in the stream gravels include diorite, volcanic rocks, agglomerate, and conglomerate. The presence of native copper and platinum, along with diorite and the other gravel constituents are all similar to features in the platinum-bearing gold placers in the Slate Creek - Miller Gulch area.

References: Moffit, 1944, p. 41, Cobb, 1973, p. 24 and 28, and Cobb, 1975.

69. Middle Fork Chistochina River **Ag, Au, PGE, Cu:**

Platinum and native copper are reported in placer gold concentrates. Other heavy minerals in the concentrates include silver, magnetite, pyrite, chromite, garnet, galena, and olivine (?). Mining began sometime after 1907 and peaked about 1941. Mining included heavy equipment and hydraulic operations; some of the deposits were tested in the 1940's by drilling. Recent mining has included mechanized, non-float, open-cut operations.

Igneous rocks similar to gold- and platinum-bearing igneous rocks described in the Slate Creek and Miller Gulch area are described in gravels on the Middle Fork.

References: Moffit, 1944, p. 37.

70. Miller Gulch, Ruby Gulch, and Slate Creek **Ag, Au, Co, Cu, Hg, Ni, PGE, (Pb):**

Iron-platinum alloy and osmiridium recovered during placer gold mining. Native copper, native mercury, and cinnabar are particularly abundant in placer concentrates. Other heavy minerals in placer concentrates include copper-gold, silver-gold (electrum), lead-gold, and silver-copper-gold alloys, pyrite, pyrrhotite, chalcopyrite, hematite, magnetite, ilmenite, garnet, chromite, cobaltite, apatite, barite, molybdenite, galena, native lead, scheelite, sphene, and zircon.

Most of the 178,000 oz of placer gold and 17,000 oz of silver production from the Chistochina Mining District came from Miller Gulch and Slate Creek. Placer gold was discovered in the district in 1899 and has been produced by a variety of hand-mining and mechanized operations until present. Platinum was discovered in concentrates from Miller Gulch, shortly after production began. Platinum was recently discovered in concentrates from Slate Creek and Ruby Gulch. Total recorded platinum production is 83 oz. Because platinum and alloys of osmium and iridium are so common in concentrates from these three creeks and because complete records of platinum production are unavailable, signigicantly larger amounts of PGE were probably produced.

Highly-differentiated intrusive igneous rocks in the Slate Creek - Miller Gulch area that contain anomalous concentrations of copper, gold, mercury, and PGE include dunite, pyroxenite, serpentinite, gabbro, hornblende gabbro, hornblendite, syenodiorite and silica-carbonate-altered diorite. These fault-bounded intrusive rocks are part of the 120-mile-long belt mentioned under Chistochina Glacier and Big Four Gulch. Anomalous metal concentrations were detected in bedrock samples by a combination of fire-assay, atomic absorption and neutron activation analyses for gold and PGE, atomic absorption for copper, and cold vapor atomic absorption for mercury. Samples from a porphyritic syenodiorite stock on Miller Gulch contain up to 400 ppb (0.012 oz/st) Pt, 65 ppb (0.0019 oz/st) Pd, 507 ppb (0.015 oz/st) Au, 700 ppb Hg, and 100-300 ppm Cu. After crushing, pulverizing, and panning, a heavy mineral concentrate produced from a rock sample from the same location contained 3,500 ppb (0.10 oz/st) Pt, 35 ppb (0.0012) Pd, 22 ppb (0.0006 oz/st) Rh, and 9 ppb Au. A magnetic hornblende gabbro sample from the west side of Miller Gulch contained 29 ppb (0.0008 oz/st) Pd. A plagioclase hornblendite sample with accessory pyrrhotite and trace chalcopyrite from the area contained 216 ppb (0.006 oz/st) Pt. A serpentinite sample from Quartz Creek contained 1,200 ppb (0.034 oz/st) Pt.

References: Chapin, 1919, pp. 137-141, Martin, 1919, p. 30-31, Moffit, 1954, p. 193, Rose, 1967, Cobb, 1973, p. 26-28, Foley and others, 1989, and Foley and Summers, 1990, and unpublished Bureau of Mines data.

71. Chistochina Glacier and Big Four Gulch **Ag, Au, Cu, Hg, Ni, PGE:**

Gold and platinum panned from glacial gravels and traces of platinum, gold, silver, and 0.2 pct Ni detected by atomic absorption procedures in dunite boulder from Chistochina Glacier. Iron-platinum alloy with 83 pct Pt and 17 pct Fe identified by electron-microprobe analysis, and minor chromite identified in placer gold concentrate from Big Four Gulch, which, has been mined intermittently by open-cut methods since the early 1950's. Other heavy minerals in placer concentrates include native copper, mercury, chromite, ilmenite, magnetite, hematite, cinnabar, garnet, and zircon.

Big Four Gulch disects a body of cumulate gabbro and hornblende gabbro that contains anomalous concentrations of copper, gold, mercury, and PGE. This gabbro body is part of an 120-mile-long belt of highly-differentiated ultramafic through siliceous, fault-bounded, intrusive igneous rocks in the east-central Alaska Range.

References: Rose, 1967, p. 21-26, Cobb, 1973, p. 26-27, Foley and others, 1989, and Foley and Summers, 1990.

72. Canwell Glacier **Asbestos, Au, Co, Cu, Ni, PGE:**

Disseminated copper-nickel sulfide minerals and massive sulfide segregations, with associated cobalt, PGE, and gold, are abundantly present in serpentinite, gabbronorite dikes and sills, and contact-related sulfide segregations near the contacts between the gabbronorite and serpentinite and between the mafic and ultramafic rocks and younger quartz diorite and granodiorite. Fibrous chrysotile is particularly abundant at the west end of the Canwell Glacier mafic-ultramafic body, which, comprises serpentinite, dunite, peridotite, plagioclase peridotite and gabbroic rocks. The Canwell glacier body is part of the highly-differentiated, 120-mile-long belt of PGE-gold-copper-nickel-cobalt-bearing igneous rocks in the east-central Alaska Range.

Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Canwell Glacier body are variably enriched in all these metals except iridium. Five gabbronorite samples contained an average of 411 ppb (0.012 oz/st) Pd and 314 ppb (0.009 oz/st) Pt. Two gabbronorite samples yielded 540 ppm and 5,950 Cu, 1,440 and 3,730 Ni, 70 and 137 ppb (0.002 and 0.004 oz/st) Au, 137 and 370 ppb (0.004 and 0.011 oz/st) Pd, and 137 and 200 ppb (0.004 and 0.006 oz/st) Pt. A quartz diorite sample with disseminated sulfides contained 340 ppm Co, 1.55 pct Cu, 2.65 pct Ni, 100 ppb (0.003 oz/st) Os, 600 ppb (0.017 oz/st) Pd, 400 ppb (0.011 oz/st) Pt, 45 ppb (0.0013 oz/st) Rh, and 40 ppb (0.0012 oz/st) Ru. A massive sulfide sample contained 600 ppm Co, 0.96 pct Cu, 3.03 pct Ni, 270 ppb (0.008 oz/st) Au, 1,700 ppb (0.050 oz/st) Pd, and 1,770 ppb (0.0516 oz/st) Pt.

References: Hanson, 1963, Bond, 1976, Barker and others, 1985, Barker, 1988, Foley and others, 1989, and Foley and Summers, 1990.

73. Glacier Lake **Au, Co, Cu, Ni, PGE:**

At the Glacier Lake Prospect, which, is within the 120-mile-long belt of mineralized mafic, ultramafic, and associated igneous rocks in the east-central Alaska Range, disseminated sulfide minerals occur in granodiorite and quartz diorite dikes.

Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Glacier Lake body are variably enriched all these metals except osmium. Up to 3 pct Ni and 2 pct Cu were detected in samples from a contact-related deposit where granodiorite and quartz diorite intrude serpentinite. Nine minerallized samples averaged 1.46 pct Cu, 2.89 pct Ni, 687 ppm Co, 25 ppb (0.0007 oz/st) Au, 90 ppb (0.0026 oz/st) Ir, 495 ppb (0.012 oz/st) Pd, 410 ppb (0.012 oz/st) Pt, 57 ppb (0.0016 oz/st) Rh, 29 ppb (0.0008 oz/st) Ru, and 25 ppb (0.0007 oz/st) Au.

References: Hanson, 1963, Bond, 1976, Barker and others, 1985, Barker, 1988, Foley and others, 1989, and Foley and Summers, 1990.

74. Emerick prospect **Au, Co, Cu, Ni, PGE::**

Pyrrhotite, pyrite, pentlandite, chalcopyrite, and trace bornite in a gabbronorite dike and enclosing serpentinite at the Emerick prospect, located on Miller Creek. The Miller Creek gabbronorite and serpentinite bodies are part of the 120-mile-long belt of mineralized mafic, ultramafic, and associated rocks in the east-central Alaska Range. Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Emerick Prospect are variably enriched in cobalt, copper, nickel, gold, palladium, platinum, iridium, osmium, and rhodium. Analyzed rock samples averaged about 1 pct each Cu and Ni, 189 ppm Co, 193 ppb (0.006 oz/st) Au, 977 ppb (0.028 oz/st) Pd, 989 ppb (0.029 oz/st) Pt, 16 ppb (0.0005 oz/st) Ir, 4 ppb (0.0001 oz/st) Os, and 17 ppb (0.0005 oz/st) Rh. PGE minerals identified by scanning-electron microscope examination include merenskyite, palarstanide, and irarsite. These generally occur as minute particles along grain boundaries between sulfide and silicate minerals.

References: Hanson, 1963, Bond, 1976, Barker and others, 1985, Barker, 1988, Foley and others, 1989, and Foley and Summers, 1990.

75. Ann Creek **Au, Co, Cu, Ni, PGE:**

Disseminated sulfide minerals in gabbronorite dikes, contact-related deposits, where diorite intrudes serpentinite, and massive sulfide deposits are present at several sites on Ann Creek. Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Ann Creek body are variably enriched in cobalt, copper, nickel, palladium, platinum, iridium, and rhodium. Samples from a massive sulfide segregation on upper Ann Creek contain up to 1.35 pct Ni, 2.65 pct Cu, 730 ppm Co, 450 ppb (0.013 oz/st) Pd, and 130 ppb (0.004 oz/st) Pt. Samples from a massive sulfide lens in the Ann Creek ultramafic body contain 3.5 pct Cu, 1.9 pct Ni, 340 ppm Co, 540 (0.016 oz/st) ppb Pd, 340 (0.010 oz/st) ppb Pt, and traces of iridium and rhodium. Sperrylite was identified in a gabbronorite sample that contained 200 ppm Co, 0.3 pct Cu, 0.44 pct Ni, 340 (0.010 oz/st) ppb Pd, and 273 ppb (0.008 oz/st) Pt.

References: Hanson, 1963, Rose, 1966a, Stout, 1976, Barker and others, 1985, Barker, 1988, Foley and others, 1989, and Foley and Summers, 1990.

76. Rainy Creek **Asbestos, Ag, Au, Co, Cr, Cu, Ni, PGE:**

At numerous locations along the two major tributaries of Rainy Creek, located in the 120-mile-long belt of mineralized mafic, ultramafic and associated igneous rocks in the east-central Alaska Range, accessory chromite and iron-copper-nickel-sulfide minerals with associated cobalt, PGE, gold, and silver occur in various lithologic associations. Disseminated and massive segregations of sulfide minerals are present in dunite, serpentinite, gabbroic rocks, andesitic and tuffaceous volcanic rocks, and dioritic intrusive rocks. Very fine-grained disseminated blebs of native copper are observed in dunite of the Rainy Creek peridotite and iron-copper-gold skarns are locally present where the igneous and volcanic rocks are in contact with sedimentary carbonate beds. The larger concentrations of sulfide minerals are present along gabbro and diorite contacts and as disseminated and massive sulfide segregations in serpentinite and gabbronorite.

Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, these metals are variably concentrated in gabbronorite and massive sulfide segregations. A sample of gabbronorite rubble from the North Fork of Rainy Creek contained 235 ppm Co, 2,500 ppm Cu, 9,000 ppm Ni, 1,070 ppb (0.031 oz/st) Pd, 725 ppb (0.021 oz/st) Pt, 300 ppb (0.009 oz/st) Ir, 70 ppb (0.002 oz/st) Rh, and 260 ppb (0.008 oz/st) Ru. Massive sulfide float from the North Fork of Rainy Creek contains 4,100 ppm Cu, 920 ppm Co, 4.5 ppm (0.13 oz/st) Ag, and 65 ppb (0.0019 oz/st) Pd. Disseminated and massive sulfide segregations near contacts between diorite and serpentinite, on the West Fork of Rainy Creek, contain up to 6.2 ppm (0.18 oz/st) Ag, 9,600 ppm Cu, 520 ppm Co, 415 ppb (0.012 oz/st) Pd, and 100 ppb (0.003 oz/st) Pt.

Throughout the peridotite mass between Ann Creek, to the east, and Rainy Creek, to the west, sulfide- and native copper-bearing clots in dunite contain consistently elevated contents of cobalt, copper, nickel, and PGE. Maximum metal contents in Rainy Creek dunite samples, as determined by neutron-activation for cobalt, copper, and nickel, and fire-assay, atomic absorption for palladium and platinum are 250 ppm Co, 4,600 ppm Cu, 3,500 ppm Ni, 310 ppb (0.009 oz/st) Pd, and 360 ppb (0.010 oz/st) Pt. Microprobe analyses of several Rainy Creek dunite samples show that platinian copper (platinum-copper alloy with 19.5-28.6 pct Pt) occurs as 5- to 20-micron grains associated with chromite, chromian-magnetite, and copper sulfide (chalcocite or digeonite?).

In the Rainy Creek area, skarn and tactite assemblages are present in several areas where sedimentary carbonate beds are intruded by basalt, gabbro, diorite, peridotite, dunite, and associated igneous rocks. Garnet-pyroxene skarn, marble, basalt, diorite, gabbro, and serpentinite contain disseminated and nearly massive pods of pyrite, pyrrhotite, and chalcopyrite. Maximum metal content in these samples, as determined by atomic absorption procedures, are 6.2 ppm (0.18 oz/st) Ag, 85 ppb (0.003 oz/st) Au, 520 ppm Co, 2 pct Cu, 960 ppm Ni.

Cobalt minerals, including erythrite, cobaltite, and safflorite ($CoAs_2$), were identified in volcanic float and rubble, along the North Fork of Rainy Creek.

Cross-fiber chrysotile with up to 1-inch-long fiber is abundant in a 400- by 900-ft area at the southeast margin of the Rainy Creek ultramafic body

Small-scale, placer gold mining is reported to have taken place intermittently since 1900 on Rainy Creek.

References: Cobb, 1973, p. 116 and 124, Rose, 1965, and 1966a, Stout, 1976, Barker, 1988, Foley and others, 1989, Foley and Summers, 1990, and unpublished Bureau of Mines data.

77. Broxson Gulch **Asbestos, Ag, Au, Co, Cr, Cu, Ni, PGE:**

Numerous iron-copper-nickel sulfide occurrences crop out in the vicinity of the two major valleys of Broxson Gulch. Mineralized mafic and ultramafic rocks in this area are within the 120-mile-long belt of related rocks in the east-central Alaska Range. Occurrences include massive sulfide lenses, veins, pods, and disseminated sulfide minerals near contacts between peridotite or serpentinite and gabbro, similar occurrences in surrounding sedimentary and volcanic rocks, and in tactite ocurrences with associated diopside, garnet, epidote, and quartz. Ore minerals include pyrite, pyrrhotite, pentlandite, chalcopyrite, marcassite, malachite, azurite, chromite, and magnetite.

Maximum metal content in massive sulfide samples from the Broxson Gulch area, as determined by atomic absorption procedures, are 13 ppm (0.38 oz/st) Ag, 760 ppm Co, 2.4 pct Cu, and 6,600 ppm Ni. Maximum precious metal content as determined by fire-assay, atomic absorption are 416 ppb (0.012 oz/st) Au, 137 ppb (0.004 oz/st) Pd, and 137 ppb (0.004 oz/st) Pt. A reddish-colored, iron oxide-stained granular dunite sample from the Broxson Gulch area contained 480 ppb (0.014 oz/st) Pd.

Abestos veinlets are common in serpentinized peridotites in the area.

Small-scale, mechanized, placer gold mining is reported on Broxson Gulch.

References: Cobb, 1973, p. 116 and 124, Rose, 1965, and 1966a, Stout, 1976, Barker, 1988, Foley and others, 1989, Foley and Summers, 1990, and unpublished Bureau of Mines data.

78. Landslide Creek **Asbestos, Ag, Au, Co, Cr, Cu, Hg, PGE, (Zn):**

Mafic and ultramafic rocks of the 120-mile-long east-central Alaska Range belt crop out near Landslide Creek. Landslide deposits on Landslide Creek comprise slump and slide blocks made up solely of magnetite-rich peridotite-cobble conglomerate. Based on neutron-activation analyses for cobalt, chromium, and nickel, atomic absorption analyses for copper, and fire-assay, atomic absorption analyses for gold, palladium, and platinum, elevated concentrations of these metals were detected in rock and placer samples from several areas in the vicinity of Landslide Creek. Abestos veinlets are common in serpentinized peridotites.

At the head of Landslide Creek, disseminated sulfide minerals are present in several ultramafic lithologies and in skarns of probable ultramafic parentage. Plagioclase-peridotite with accessory pyrite, pyrrhotite, and chalcopyrite contained 110 ppb (0.003 oz/st) Au, 185 ppm Co, 4,036 ppm Cr, 1,540 ppm Cu, 3,520 ppm Ni, 300 ppb (0.009 oz/st) Pd, and 380 ppb (0.012 oz/st) Pt. A peridotite sample contained 168 ppm Co, 5,370 ppm Cr, 236 ppm Cu, 2,360 ppm Ni, and 25 ppb (0.0007 oz/st) each, Pd and Pt. Serpentinized peridotite samples with accessory pyrite, pyrrhotite, chalcopyrite, very-fine grained chromite, and rarely, very fine blebs of native copper, contain up to 214 ppm Co, 4,030 ppm Cr, 360 ppm Cu, 3,260 ppm Ni, 100 ppb (0.0029 oz/st) Pd, and 90 ppb (0.0026 oz/st) Pt. A sample of magnetite-chalcopyrite-epidote-diopside skarn contained 130 ppb (0.004 oz/st) Au and 5,000 ppm Cu.

A prominent hill on the west side of Landslide Creek is capped by conglomerate that is made up almost entirely of peridotite and dunite with minor gabbro. Angular to sub-rounded clasts and pebbles of magnetite, up to 2 cm across, are particularly abundant in the matrix of the conglomerate. The eastern slope of this hill, to the floor of the Landslide Creek valley, is covered with landslide deposits that were derived from the ultramafic-rich conglomerate. Grab samples of the conglomerate and heavy mineral concentrates produced by panning pulverized conglomerate and regolith overlying the conglomerate were all found to contain traces of gold and platinum; maximum values detected were 102 ppb (0.003 oz/st) Au, 150 ppb (0.0044 oz/st) Pd, and 240 ppb (0.007 oz/st) Pt. Abundant pyrite and cinnabar, with fine gold particles, weighing up to 4 milligrams were panned from alluvium along Landslide Creek.

South of the conglomerate-capped hill, in a south-facing gully, disseminated pyrite, pyrrhotite, and chalcopyrite were observed in siliceous veins cutting diorite and quartz monzonite. The diorite contains elongated segregations of gabbro and hornblende gabbro. Based on neutron-activation analyses for gold and zinc, diorite from this location contained 310 ppb (0.009 oz/st) Au and 450 ppm Zn. A sample from a gabbro segregation in the diorite contained 270 ppb (0.008 oz/st Au) and 310 ppm Zn.

References: Rose, 1965,and 1966a, Stout, 1976, Foley and others, 1989, Foley and Summers, 1990, and unpublished Bureau of Mines data.

79. Eureka Glacier **Ag, Ag, Co, Cu, Ni, PGE:**

Sill-form masses of mafic and ultramafic rocks of the 120-mile-long east-central Alaska Range belt crop out along ridges above the east and west sides of Eureka Glacier and one mile farther to the west, on the next high ridge. Based on inductively-coupled plasma analyses for gold, silver, cobalt, copper, and nickel, and fire-assay, atomic absorption analyses for palladium and platinum, trace to elevated concentrations of these metals were detected in select samples from this area. Sepentinized plagioclase peridotite, peridotite, and gabbro samples with accessory chalcopyrite, pyrrhotite, native copper, chromite, and magnetite contained up to 4 ppm (0.12 oz/st) Ag, 61 ppb (0.0017 oz/st) Au, 110 ppm Co, 5,260 ppm Cr, 2,700 ppm Ni, 220 (0.006 oz/st) Pd, and 300 (0.009 oz/st) Pt. Neutron-activation analyses for silver, gold, cobalt, chromium, copper, nickel and fire-assay, atomic absorption analyses for palladium and platinum for a similar suite of samples from the same area detected up to 3.5 ppm (0.10 oz/st) Ag, 80 ppb (0.0018 oz/st) Au, 90 ppm Co, 3,812 ppm Cr, 2,680 ppm Cu, 3,640 ppm Ni, 370 ppb (0.011 oz/st) Pd, and 550 ppb (0.016 oz/st) Pt. The highest palladium and platinum concentrations were detected in a red iron oxide-stained, sulfide-rich olivine gabbro, which upon microprobe examination, was found to contain minute particles of moncheite (Pt,Te) along grain boudaries between chalcopyrite and ferromagnesian silicate minerals.

References: Rose, 1965, and 1966a, Stout, 1976, Foley and others, 1989, Foley and Summers, 1990, Balen, 1990, Foley, 1991, Kurtak and others, 1991, and unpublished Bureau of Mines data.

80. Fish Lake **Cu, Ni, PGE:**

Serpentinized peridotite sample with accessory pyrrhotite, pentlandite, chalcopyrite, and magnetite contained 70 ppb (0.0020 oz/st) Pd and 70 ppb (0.0020 oz/st) Pt.

References: Rose, 1966a, Stout, 1976, and unpublished Bureau of Mines data.

81. Butte Creek: **Ag, Au, Co, Cr, Cu, Ni, PGE:**

At the southwesten end of the 120-mile-long east-central Alaska Range belt of mafic and utramafic rocks is an elogante, fault-bounded, sill-form mass of serpentinite, peridotite, troctolitic gabbro with accessory copper-colored biotite, and leucocratic intrusive rocks. Sulfide minerals including pyrite, pyrrhotite, pentlandite, and chalcopyrite, disseminated and massive magnetite, and accessory chromite are locally concentrated in these rocks. Neutron-activation analyses for silver, gold, cobalt, chromium, copper, nickel and fire-assay, atomic absorption analyses for palladium and platinum indicate that these rocks contain up to 300 ppm Co, 1,400 ppm Cu, 3,500 ppm Ni, 28 ppb (0.0008 oz/st) Pd, 140 ppb (0.004 oz/st) Pt, and traces of gold and silver. Gold was identified in placer samples collected downstream from this area.

References: Foley and others, 1989, Foley and Summers, 1990, Balen, 1990, Foley, 1991, Kurtak and others, 1991, and unpublished Bureau of mines data.

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82. Long Creek: Ti:

Disseminated ilmenite grains are reported in fine-grained gabbro in the Long Creek area.

References: Hawley and Clark, 1973, and Jones and others, 1980.

83. Copeland Creek-Ohio Creek Co, Cr, Ni, PGE:

Small chromite pods and accessory chromite with 99 ppb (0.003 oz/st) Pd and 97 ppb (0.003 oz/st) Pt detected by fire-assay, atomic absorption in 1,000-ft-wide by 3-mile-long fault-bounded serpentinized and silica-carbonate-altered dunite and peridotite mass.

References: Hawley and Clark, 1973, and 1974, Jones and others, 1980, and unpublished Bureau of Mines data.

84. Eldridge Glacier Ag, Au, Co, Cu, Ni:

Pyrite and chalcopyrite-rich quartz rock in malachite-stained serpentinite with up to 7.5 pct Cu, 1.5 pct Ni, 200 ppm Co, 15 ppm Ag, 100 ppb (0.003 oz/st) Au detected by emission spectrography.

References: Hawley and others, 1969, Hawley and Clark, 1973, and 1974, and Jones and others, 1980.

85. Cache Creek-upper Kahiltna River Valley Cr, PGE, (Au, REE, Sn, Th, Ti, U, W):

Small amounts of platinum recovered during placer gold mining on Cache Creek, Peters Creek, Poorman Creek, Willow Creek, Ruby Creek and other streams in the upper Kahiltna River Valley. Other heavy minerals in placer concentrates include cassiterite, scheelite, magnetite, monazite, uranothorianite, rutile, and garnet. Chromite and platinum in the concentrates are probably derived from silica-carbonate-altered mafic and ultramafic dikes in the region. Mining operations in the Cache

Creek - Peters Creek area have employed bucket-line dredges, hydraulic plants, and most recently, mechanized non-float equipment.

References: Mertie, 1919 and Robinson and others, 1955, p. 22, Clark and Hawley, 1968, Cobb, 1973, p. 20-23, Hawley and Clark, 1973, and 1974.

86. Yentna and Lacuna Glaciers **Cr:**

Chromite occurs as disseminated grains, schlieren, and massive lenses in dunite at six locations. The largest of these is a 60-ft-long by 8-ft-wide lens of nearly massive chromite.

References: Hawley and Clark, 1973, and 1974, and Reed and others, 1978.

87. Shellabarger Pass **Ag, Cu, PGE, (Pb, Zn):**

Massive and disseminated sulfide minerals are concentrated in interbedded sedimentary and volcanic rocks in the lower part of a structural trough. The interbedded lithologies include chert, dolomite, siltstone, shale, volcanic graywacke, basaltic aquagene tuff, sedimentary breccia, and conglomerate. The interbedded rocks are overlain by submarine basaltic pillow flows and subordinate interbedded agglomerate, flow breccia, and tuff.

A composite pluton comprising primarily gabbro, with less abundant mafic and ultramafic rocks including hornblende gabbro, olivine gabbro, magnetite gabbro, biotite dunite, and silica-carbonate rock (listwaenite?) crops out near the above occurrence. A pan concentrate sample from a creek to the west contained 840 ppb (0.025 oz/st) Pt. Mineral deposits in the area consist of up to 15 pct sulfides, including fine-grained pyrite, marcasite, sphalerite, and galena, in siderite, calcite, quartz, and dolomite. Average grades are estimated at 1-1.5 pct Cu, 0.8-1.7 pct Zn, 0.5 pct Pb, and 0.9-2.4 oz/st Ag.

References: Reed and Eberlein, 1972, Reed and Nelson, 1980, unpublished U.S. Geological Survey data, and unpublished U.S. Bureau of Mines data.

88. Yentna River Cr, PGE, (Au):

Chromite reported in placer gold concentrates at several locations in the upper Yentna River Valley is probably eroded from the fault-bounded, serpentinized and silica-carbonate-altered ultramafic rocks at the headwaters of the River.

Several composite Cretaceous plutons comprising minor peridotite, lamprophyric and alkaline mafic-ultramafic igneous rocks and more abundant monzonite, syenite, quartz syenite, and granitic rocks, all contianing biotite, crop out at the headwaters of the Yentna River and adjacent tributaries. Three separate pan concentrate samples from creeks that drain these plutons contained maxima of 70 ppb (0.002 oz/st) Pd, 300 ppb (0.009 oz/st) Pt, and 840 ppb (0.025 oz/st) Pt.

References: Hawley and Clark, 1973, Reed and Eberlein, 1972, Reed and Nelson, 1980, unpublished U.S. Geological Survey data, and unpublished U.S. Bureau of Mines data.

89. Kichatna River PGE, (Au):

Platinum recovered during placer gold prospecting and mining may be derived from composite Cretaceous plutons in the Kichatna River headwaters like those described in the preceding description of the Yentna River area.

References: Martin, 1919, p. 33, Cobb, 1973, p. 23, Reed and Eberlein, 1972, Reed and Nelson, 1980. unpublished U.S. Geological Survey data, and unpublished U.S. Bureau of Mines data.

90. Lake Creek: PGE, (Au):

Minor platinum reported in placer gold concentrates. Iron-platinum alloy identified by microprobe examination. Recent exploration by trenching indicates that gold and PGE in the Lake Creek area are derived from Tertiary conglomerate of the Tyonek Formation. Other heavy minerals in placer concentrates include magnetite, ilmenite (?), chromite, olivine, garnet, and minor mercury. Placer mining is expected to take place in 1991.

References: Martin, 1919, p. 33, Cobb, 1973, p.22, and unpublished Bureau of Mines data.

91. Lower Kahiltna River **PGE, (Au):**

Small amount of PGE recovered during small-scale placer gold mining and prospecting at several sites, including Shulin (Sholan) Bar, Red Hill Bar, and Boulder Bench. River bars were prospected for platinum by hand-drilling and power-drilling in 1917.

References: Mertie, 1919, p. 262-263, Robinson and others, 1955, p.22, Cobb, 1973, p.23.

92. Chulitna River: **PGE, (Au):**

Platinum recovered during placer gold prospecting and mining.

References: Martin, 1919, p. 33.

Southwestern Alaska - Southwestern Alaska metallogenic province

93. Disappointment Creek, Willow Creek, and Wilson Creek **PGE, (Au):**

Small amounts of platinum, probably eroded from greenstone in the region, was reported in placer gold concentrates. Mining began on Wilson Creek in 1914, and continued until at least 1965.

References: Harrington, 1918, p. 59, West, 1954, p. 8, Cobb, 1973, p. 107 and 162, and Cobb, 1975.

94. Ptarmigan Creek **Jade:**

Mining claim located for jade in 1979.

References: Unpublished Bureau of Mines data.

95. Bear Creek **PGE, (Au, Hg):**

Tributary to Tuluksak River. Small amount of platinum in placer gold concentrates. Cinnabar, possibly derived from diabasic dikes and sills in the region, was abundant in the concentrates from Bear Creek. Mining took place from about 1909 until 1964 when dredges in the area shut down.

References: Mertie, 1969, p. 89-90, Cobb, 1973 and 151, and Cobb, 1975.

96. Tuluksak River **PGE, (Au):**

Small amount of platinum recovered with gold in placer concentrates. Mining took place from 1909 until 1964 when placer dredges in the area shut down.

References: Hoare and Coonrad, 1959, Cobb, 1973, p. 42 and 44, and Cobb, 1975.

97. Bear Creek and Slate Creek **PGE, (Au):**

Small amount of PGE produced during prospecting by the Goodnews Bay Mining Company and combined with the PGE produced from the Salmon River placers. 6,500 ppb (0.19 oz/st) Pt in placer sample from Bear Creek and >10,000 ppb (0.29 oz/st) Pt with 325 ppb (0.009 oz/st) Pd in placer sample from Danielson Creek, tributary of Bear Creek.

References: Mertie, 1969, p. 89-90, and Fechner, 1988.

98. Snow Gulch, Butte Creek, and Kowkow Creek **PGE, (Au):**

Small amount of PGE produced during prospecting by the Goodnews Bay Mining Company and other operators and combined with the PGE produced from the Salmon River placers. Pan concentrate sample from tailings contained 412 ppb (0.012 oz/st) Pt.

References: Smith, 1930, p. 52-53, Mertie, 1969, p. 89-90, and unpublished Bureau of Mines data.

99. Mitlak Mountain **Cr:**

Accessory chromite in serpentinized peridotite.

References: Foley and others, 1985 and 1986, and unpublished Bureau of Mines data.

100. Tatlignagpeke Mountain **Cr, PGE:**

Accessory chromite and traces of palladium and platinum in dunite and peridotite.

References: Foley and others , 1985, 1986, and unpublished Bureau of Mines data.

101. Goodnews Bay-Salmon River **Au, Cr, PGE:**

Over 650,000 oz PGE and about 10,000 oz Au were produced from placers by the Goodnews Bay Mining Company and other operators since 1927. The source for the PGE is thought to be the Goodnews Bay Ural-Alaskan-type, zoned ultramafic complex at Red and Susie Mountains. No economic lode deposits have been found in the complex, which, has been explored as recently as 1987 and 1988 by Ashton Mining Company.

Geochemical data and the common presence of intergrown chromite and magnetite with platinum-iron alloy in placer concentrates indicate that PGE are concentrated with chromite and magnetite in dunitic portions of the Goodnews Bay complex. Anomalous platinum was detected in pan-concentrated soil samples at the summit and south and northeast ends of the complex and anomalous platinum and palladium, in some cases associated with copper-iron sulfide minerals, were detected in magnetite clinopyroxenite border zones by Ashton and by the Bureau of Mines (personal communication, Toni Hinderman, Alaska Earth Resources, Anchorage, Alaska).

In the placers near Red Mountain, platinum is the most abundant PGE in concentrates and occurs primarily as platinum-iron alloy of variable composition. Osmiridium and iridosmine are the next most abundant PGE minerals but make up less than 10 pct of the precious metal concentrates. Other PGE minerals include minor sperrylite, hollingworthite, and Ir-Fe, Ir-S-As-Rh-Pt-Fe, Rh-As-Pd-Ni, and Pb-S-Rh-Fe-Ir minerals associated with magnetite. Gold makes up between less than 1 pct and 5 pct of the precious metal concentrates. Remaining resources include an estimated 40 million yd^3 of tailings grading between 0.0013 and 0.017 oz/yd^3, and low grade (0.0021 oz/yd^3) unmined, unfrozen, measured and indicated resources in the lower bench paystreak, which is up to 200 ft deep. Additional unmeasured alluvial placer resources are indicated at the northwest side of Red Mountain.

Gold and PGE have been geochemically detected and mineral grains identified in offshore and onshore marine placers from Goodnews Bay to Chagvan Bay, to the north and south of Red Mountain. Identified PGE minerals include isoferroplatinum, osmiridium, platiniridium, sperrylite, and moncheite. Also present in the samples are chromite, magnetite, ilmenite, zircon, cinnabar, and native mercury. Based on bathymetry surveys, magnetometer surveys, seafloor sampling, limited drilling, and scanning eletron microscope studies, several deposit types have been identified or suggested. These include: onshore, swashzone, heavy mineral concentrations and drowned alluvial and marine placers. Magnetometer survey data indicate that the Goodnews Bay complex extends at least six miles offshore, and reworked residual submarine placers may exist on top of the submerged ultramafic bedrock.

References: Harrington, 1921, Mertie, 1940, 1969, and 1976, Bird and Clark, 1976, Rosenblum and others, 1982 and 1986, Carlson, 1983, Ulrich, 1984, Southworth, 1984c and 1986, Southworth and Foley, 1986, Barker and Lamal, 1988, Fechner, 1988, and Zelenka, 1988.

102. Cape Newenham, Security Cove and Chagvan Mountain — **Asbestos, Au, Cu, Ni, PGE:**

Cross-fiber chrysotile in serpentinized peridotite and serpentinized dunite, up to 2,200 ppm Cu and 1,300 ppm Ni detected by atomic absorption procedures in serpentinized peridotite and gabbro with accessory pyrite, pyrrhotite, and pentlandite, and traces of gold in sulfide-bearing gabbros.

Osmiridium, and platinum-iron alloy grains with osmiridium inclusions identified in placer concentrate from streams draining till-covered Cape Newenham ophiolite.

References: Fechner, 1988, and unpublished Bureau of Mines data.

103. Hagemeister Straight **Au, Cu, Cr, (Pb, Mn, Zn):**

Chalcopyrite, pyrite, galena, and sphalerite observed in gossans in mafic to intermediate volcanic rocks and diabase along shore. Based on fire-assay, atomic absorption analyses, select samples from quartz-carbonate-sulfide vein at wall of diabase dike contained up to 762 ppb (0.022 oz/st) Au. Manganese oxide- and ferricrete-cemented gravels were observed in bluffs along the coastline. Trace chromite is reported in beach sand samples.

References: Berryhill, 1963, p. 17 and unpublished Bureau of Mines data.

104. Kemuk Mountain **Cu, Fe, Ti**

Based on airborne magnetometer surveys in 1957 and diamond-drilling in 1958 and 1959, Humble Oil and Refining Company delineated 2.5 billion st of magnetite clinopyroxenite ore containing 15-17 pct total Fe in a buried Ural-Alaskan-type ultramafic complex. The deposit is buried beneath alluvium and glacial till, in the Nushagak River lowlands, east of Kemuk Mountain. Iron assays indicate that magnetic iron grades in the titaniferous magnetite are between 10.5 and 12 pct. Copper minerals are reported along a faulted portion of the complex.

References: Humble Oil and Refining Company, 1959, Berg and Cobb, 1967, p. 11.

South-Central Alaska - Chugach-Kodiak metallogenic province

105. Halibut Bay and Sturgeon River **Ag, Au, Co, Cr, Cu, Ni, PGE:**

Based on surface measurements, 201,000 st Cr_2O_3 are estimated in seven deposits in dunitic portion of cumulate ultramafic mass with interlayered peridotite and clinopyroxenite. The largest deposit contains 196,000 tons Cr_2O_3 and is a 1,000-ft-long, low-grade banded zone averaging 5 pct chromite. Chromite is abundant in pan-concentrate samples from valleys draining the ultramafic rocks. Minor wispy chromite segregations and schlieren occur throughout dunite in the Halibut Bay and nearby Sturgeon River mass. Stannopalladinite, chalcocite, covellite, cobaltian pentlandite, pyrrhotite, chalcopyrite, uvarovite, and villamanite were identified by scanning-electron and ore microscope examination of peridotite with both orthopyroxene and clinopyroxene. Based on inductively-coupled plasma analyses, a flotation concentrate produced from that sample contained 0.083 pct Co, 11.8 pct Cu, 1.55 pct Ni, 11,522 ppb (0.336 oz/st) Pd, 5,453 ppb (0.159 oz/st) Pt, 4,561 ppb (0.133 oz/st) Au, and 24 ppm (0.70 oz/st) Ag. Grab samples of peridotite and olivine pyroxenite from this location contain up to 3,629 ppm Cu, 839 ppm Ni, and 7,700 ppm Cr, 420 ppb (0.012 oz/st) Pt, 480 ppb (0.014 oz/st) Pd.

References: Beyer, 1980, Dahlin and others, 1985, Foley and Barker, 1985, and Foley and others, 1985, 1986, and 1989, and unpublished Bureau of Mines data.

106. Gurney Bay **Cr:**

Minor disseminated and banded chromite in dunite.

References: Dahlin and others, 1985, Foley and Barker, 1985, Foley and others, 1985 and 1986.

107. Ayakulik Beach and Canvas Island **Cr, PGE, (Au):**

Minor platinum and abundant "chromic sands" in heavy mineral concentrates from beach sands and small amount of platinum recovered during placer gold mining. Analyses indicate Pt, Ir, and Os are the most abundant PGE present.

References: Maddren, 1919, p. 316-317, and Cobb, 1975.

108. Grant Lagoon **Cr:**

Minor disseminated chromite in dunite.

References: Dahlin and others, 1985, Foley and Barker, 1985, and Foley and others, 1985 and 1986.

109. Karluk **Cr:**

Accessory chromite in dunite.

References: Beyer, 1980.

110. Saddle Mountain **Cr:**

Minor banded and disseminated chromite in dunite.

References: Foley and Barker, 1985, Foley and others, 1985 and 1986.

111. Miners Point **Cr:**

Minor banded and disseminated chromite in dunite.

References: Foley and Barker, 1985, Foley and others, 1985 and 1986.

112. Claim Point **Cr, PGE:**

Twenty-two hundred short tons of chromite ore was produced in 1917 and 1918. 90,000 st Cr_2O_3 are estimated in 16 deposits of banded chromite in dunite with grades ranging from 5 to 30 pct Cr_2O_3. Eight other deposits with no reserve estimates have been described. A tabled chromite concentrate from one sample at Claim Point contained 1,166 ppb (0.034 oz/st) Pt and 2,469 ppb (0.072 oz/st) Pd. Fourteen grab and chip samples from the same chromite mass contained from less than 15 to 100 ppb Pt and from 2 to 30 ppb Pd.

References: Gill, 1922, Guild, 1942, Sanford and Cole, 1949, Burns, 1983 and 1985, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others, 1985 and 1986, and unpublished Bureau of Mines data.

113. Port Graham **Cr:**

Chromite-bearing ultramafic rocks were observed over a large area in the Port Graham dunite-peridotite mass.

References: Anaconda Minerals Company, 1981.

114. Red Mountain **Cr, PGE:**

About 29,000 st of ore containing from 38 to 43 pct Cr_2O_3 was produced between 1943 and 1958. Reserve estimates include 1.6 million st of contained Cr_2O_3 in thirty-three deposits. 97,000 st Cr_2O_3 are in 20 relatively high-grade deposits with over 20 pct chromite. The bulk of the reserves, 1.487 million st, are in three low-grade deposits with 5 to 6 pct Cr_2O_3. These are the Turner Stringer Zone (1.25 million st Cr_2O_3), the Star Stringer Zone (208,000 st Cr_2O_3), and the Horseshoe Stringer Zone (29,000 st Cr_2O_3). Based on fire-assy, atomic absorption analyses, chip samples across the Turner Stringer Zone contained up to 485 ppb (0.014 oz/st) Pd and 690 ppb (0.020 oz/st) Pt.

References: Gill, 1922, Guild, 1942, Wells and others, 1957, Anaconda Minerals Company, 1981, Burns, 1983 and 1985, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others, 1985, 1986, and 1989.

115. Windy River **Cr:**

556,000 st Cr_2O_3 in low-grade placer deposits with 1.33 pct Cr_2O_3 eroded from Red Mountain.

References: Rutledge, 1946, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others 1985 and 1986.

116. Eklutna **Cr, PGE:**

1,000 st Cr_2O_3 in four deposits up to 175-ft-long and 40-ft-wide plus two other reported occurrences . Based on fire-assay, emission spectrography analyses, ten samples, including gabbro, hornblendite, pyroxenite, peridotite, and dunite contained averages of 46 ppb Pt and 40 ppb Pd with maxima of 100 ppb each, Pd and Pt, in pyroxenite with associated magnetite. A sample of coarse-grained, cumulate clinopyroxenite with accessory interstitial pyrrhotite was analyzed for gold, palladium, and platinum by fire-assay, directly-coupled plasma techniques and for cobalt, chromium, copper, nickel, and silver by inductively-coupled plasma procedures; the sample contained 55 ppm Co, 1,584 ppm Cr, 221 ppm Cu, 459 ppm Ni, 1.4 ppm (0.041 oz/st) Ag, 32 ppb (0.0009 oz/st) Au, 94 ppb (0.0027 oz/st) Pd, and 91 ppb (0.0027 oz/st) Pt.

References: Gates, 1942, Bjorklund and Wright, 1948, Rose, 1966b, Clark and Greenwood, 1972, p. C159, Burns, 1983 and 1985, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others, 1985, 1986, and 1989, and unpublished Bureau of mines data.

117. Willow Creek **Soapstone, PGE:**

An open-cut soapstone mine was observed at the head of Willow Creek in 1978. Traces of Pd (0-30 ppb) and Pt (0-30 ppb) were detected by fire-assay and up to 5,000 ppm Cr and 2,000 ppm Ni were detected by emission spectroscopy in serpentinite samples.

References: Csejtey and Evarts, 1979 and unpublished Bureau of Mines data.

118. Wolverine Complex **Cr:**

From 10,000 to 28,000 st Cr_2O_3 in two deposits of banded, nodular, and disseminated chromite in dunite with associated peridotite and pyroxenite. The larger deposit contains between 10 and 20 pct chromite and is discontinuously exposed for 2,000 ft.

References: Clark, 1972, Burns, 1983 and 1985, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others, 1985 and 1986, and Newberry, 1986.

119. Metal Creek **PGE, (Au):**

Small amount of platinum recovered during intermittent placer gold mining.

References: Cobb, 1973, p. 17, and Cobb, 1975.

120. Alfred Creek **PGE, (Au):**

Small amount of platinum reported in gold placers.

References: Brooks, 1925, p. 30, and Cobb, 1975.

121. Albert Creek **PGE, (Au):**

Small amount of platinum produced during placer gold mining in 1913.

References: Cobb, 1973, p. 29, and Cobb, 1975.

122. Barnette Creek **Cr:**

Accessory disseminated chromite in small fault-bounded serpntinite mass less than 500 ft across in maximum dimension.

References: Foley and Barker, 1985, and Foley and others, 1985 and 1986.

123. Bernard Mountain **Cr, PGE:**

Based on surface measurements, inferred reserve estimates include 343,000 st Cr_2O_3 in seven low-grade deposits of banded and disseminated chromite in dunite. Numerous other small and unmeasured occurrences exist. Up to 823 (0.024 oz/st) and 1,749 ppb (0.051 oz/st) Pd were detected by fire-assay, neutron activation analyses in two high-chromium tabled concentrates from a 134-lb, high-chromium chromite sample, but, no PGE were detected in replicate samples from that location or other samples from Bernard Mountain.

References: Pittman, 1957, Wells, 1957, Berg and Cobb, 1967, p. 52, Hoffman, 1972, Burns, 1983 and 1985, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others, 1985, 1986, 1988, and 1989, and Newberry, 1986.

124. **Sheep Hill** **Cr, PGE:**

Based on surface measurements, inferred reserve estimates are from 45,000 to 70,000 st Cr_2O_3 in two low-grade, high-iron chromite deposits with associated PGE. Based on fire-assay, neutron activation analyses, samples from a 210- by 300-ft area with 5 pct chromite contained up to 927 ppb (0.27 oz/st) total PGE. Maximum results for individual elements include 412 ppb (0.012 oz/st) Pd and 515 ppb (0.015 oz/st Pt with associated Ir (< 75 ppb), Os (< 27 ppb), Rh (< 72 ppb), and Ru (< 45 ppb). Pt/Pt+Pd values range from 0.57 to 0.75.

References: Berg and Cobb, 1967, p. 52, Burns, 1983 and 1985, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others 1985, 1986, 1988, and 1989, and Newberry, 1986.

125. **Dust Mountain** **Cr, PGE:**

Based on surface measurements, inferred reserve estimates include from 2.6 million to 5.3 million st Cr_2O_3 in a 190- by 3,600- ft area comprising dunite, clinopyroxenite, clinopyroxene-rich peridotite, and high-iron chromitite, with associated PGE and very fine blebs of native copper. PGE are preferentially associated with high-iron chromitites in clinopyroxene-rich horizons. Based on fire-assay, neutron activation analyses, chromitite samples from this area contain up to 0.6 oz/st PGE (11,936 ppb Pd, 8,918 ppb Pt, 330 ppb Ir, 87 ppb Os, 550 ppb Rh, and 140 ppb Ru). Pt/Pt+Pd ratios range from 0.44 to 0.87. Identified PGE minerals include PGE-amalgams, arsenides, alloys, and sulfides that are concentrated in fractures and grain boundaries in serpentinized, metasomatically-, and magmatically-altered high-iron chromitites and maximum PGE concentrations were observed in malachite- and native copper-bearing, magnetic chromitites.

References: Pittman, 1957, Wells, 1957, Burns, 1983 and 1985, Dahlin and others, 1985, Foley and Barker, 1985, Foley and others, 1985, 1986, 1988, and 1989, and Newberry, 1986.

126. Liberty Falls **Mn:**

Manganite in 40-ft-long, up to 2-ft-thick lens in Strelna greenstone outcrop. Several other similar lenses reported along strike to south. Select samples contained up to 58.7 pct Mn.

Referernces: Jasper, 1967, p. 4, and Berg and Cobb, 1967, p. 49.

127. Spirit Mountain **Ag, Au, Co, Cu, Ni, PGE:**

Disseminated and massive iron-copper-nickel sulfide minerals in sill-form peridotite-pyroxenite intrusions. Reserve estimates include 6,500 st of material grading from 0.22 pct Ni and 0.12 pct Cu to 7.61 pct Ni and 1.56 pct Cu. Ore minerals include pyrrhotite, pentlandite, bravoite, chalcopyrite, chalcocite (?), and hematite (?). Heads from a metallurgical sample contained 1.16 pct Ni, 0.76 pct Cu, 0.04 pct Co, 0.02 pct Zn, 240 ppb (0.007 oz/st) Au, 2,640 ppb (0.077 oz/st) Ag, 206 ppb (0.006 oz/st) Pt, and 171 ppb (0.005 oz/st) Pd; 92 pct of Cu, 79 pct of Ni, 76 pct of Co, and minor Au, Ag, Pt, and Pd were recovered during flotation tests.

References: Kingston and Miller, 1945, Pierce, 1946, Herreid, 1970, and unpublished Bureau of Mines data.

128. Hanagita River **Cr:**

A 2-in clot of massive chromite in wehrlite and accessory disseminated chromite in dunite.

References: Foley and Barker, 1985, and Foley and others, 1985 and 1986.

129. Chakina River **Cr:**

Disseminated chromite in serpentinized peridotite and dunite.

References: Foley and Barker, 1985, and Foley and others, 1985 and 1986.

South-Central Alaska - Gulf of Alaska metallogenic province

130. Resurrection Peninsula **Ag, Au, Cr, Cu, Ni, (Cd, Pb, Zn):**

Numerous abandoned mines, prospects, and reported mineral occurrences in mafic volcanic and mafic and ultramafic plutonic rocks. Volcanic rocks include pillow basalt, diabase, sheeted dikes, and greenstone. Plutonic rocks include gabbro, dunite, and peridotite. Mines, prospects, and mineral occurrences include disseminated sulfide minerals, massive sulfide veins and pods, and quartz-calcite veins and stringers in breccia zones and shear zones in the volcanic and plutonic rocks. Mineral occurrences are also reported in metasandstone. Ore minerals include pyrite, pyrrhotite, chalcopyrite, arsenopyrite, sphalerite, galena, hematite, limonite, and magnetite. Underground mine workings are reported at several sites but no production records are available.

References: Jansons and others, 1984, and Nelson and others, 1987.

131. Latouche Island **Asbestos, Ag, Au, Cu, (Zn):**

Numerous abandoned mines, prospects, and reported mineral occurrences exist on Latouche Island and on Elrington Island, across Latouche Passage to the west. Massive sulfide lenses and sulfide stringers cut mostly greywacke, shale, and slate but are also reported in nearby greenstone bodies. Reported ore minerals include pyrite, pyrrhotite, chalcopyrite, cubanite, galena, sphalerite, and native copper. Combined production, through 1930, from the the Beatson Mine, the Duchess Claim, the Blackbird Mines, and the Seattle Prospect totals 183.4 million lb Cu, 1.5 million oz Ag, and 484 oz Au. Significant copper reserves remain in the mines that produced and in the Duke Mine which was flooded.

References: Jansons and others, 1984, and Crowe and others, 1988.

132. Chenega Island **Cu, Mn:**

Between 20,000 and 40,000 short tons of Mn are estimated in 115,000 to 230,000 short tons that contain about 17 pct Mn. The manganiferous iron deposit comprises rhodonite, pyroxmangite, and rhodochrosite at the highly altered contact between siliceous greenstone and phyllitic, quartzofeldspathic argillite of the Eocente to Paleocene Orca Group. Pyrite, pyrrhotite, and chalcopyrite are locally abundant in the altered and mineralized zone.

References: Kurtak, 1982, Jansons and others, 1984, and unpublished Bureau of mines data.

133. Knight Island **Ag, Cu, Ni, (Pb, Zn):**

Fifty-eight abandoned mines, prospects, and reported mineral occurrences exist on Knight Island. Most of these are in greenstone and mafic volcanic rocks or are near contacts between clastic sedimentary rocks and greenstones or mafic volcanic rocks. Ore minerals include chalcopyrite, covellite, bornite, native copper, sphalerite, galena, limonite, malachite, pyrite, and pyrrhotite. Ore minerals are concentrated as disseminated grains and massive segregations in greenstone, along shear zones in greenstone, in quartz veins, and in nearby sedimentary rocks. Sedimentary rocks include graywacke, slate, shale, schist, and chert.

Extensive shallow underground workings, prospect pits, and ore and tailing dumps remain at these sites. Minor copper production is reported for many of the sites and indicated and inferred copper reserves are reported for a few of the larger deposits.

References: Jansons and others, 1984, and Nelson and others, 1987.

134. Port Valdez area **Ag, Au, Ni, (Pb, Zn):**

Numerous abandoned mines, including the Midas, Cliff, and Ramsay-Rutherford mines, prospects and reported mineral occurrences. High grade quartz-gold veins, mostly cutting sedimentary rocks but locally in greenstone, accounted for production of about 64,000 oz Au, 42,000 oz Ag, and 3.4 million lb Cu. Gold and sulfide minerals are mostly present in quartz veins, stringers, and ribbon quartz in slate, shale, and graywacke. Minor production is reported from sites where ore minerals are contained in greenstone and basic dikes. Ore minerals include native gold, chalcopyrite, bornite, pyrite, pyrrhotite, galena, sphalerite, and arsenopyrite.

References: Jansons and others, 1984, Nelson and Koski, 1987, and Crowe and others, 1988, p. 153.

135.. Port Fidalgo area **Ag, Au, Co, Cu, (Pb, W, Zn):**

Abandoned mines, including the Fidalgo, Sclosser, South Landlocked Bay, Threeman, and Boulder Bay mines, numerous prospects and mineral occurrences. Massive sulfide lenses, disseminated sulfide minerals, quartz-sulfide veins and veinlets, and shear zone deposits in slate, greenstone, and along contacts between the two rock types. Ore minerals include chalcopyrite, pyrite, pyrrhotite, arsenopyrite, galena, sphalerite, scheelite, malachite, and azurite. Recorded production includes 6 million lb Cu and 6,700 oz Ag.

References: Jansons and others, and Crowe and others, 1988.

136. Hinchinbrook Island **Cu, Mn:**

Up to 35 pct Mn is estimated in rubblecrop over a 3,000-ft^2-area in metsasediments and pillow basalt of the Paleocene (?) Orca Group. Manganese oxide minerals and the manganese silicates, rhodonite and tephroite were identified. Native copper is reported as an accessory mineral in greenstone on the island.

References: Goodfellow and others, 1984, and Jansons and others, 1984.

137. Cordova area **Ag, Au, Cu, (Pb, Zn)**

Numerous abandoned mines, prospects, and mineral occurrences in shear zones and quartz veins in greenstone and nearby clastic sedimentary rocks. Ore minerals include chalcopyrite, bornite, chalcocite, malachite, pyrite, pyrrhotite, sphalerite, and galena. Minor recorded production.
References: Jansons and others, 1984.

References

Anaconda Minerals Company, 1981, 1981 Annual report on Red Mountain: Anaconda Minerals Company, Anchorage Alaska, 43 p.

Anderson, Eskil, 1945, Asbestos and jade occurrences in the Kobuk River region, Alaska: Alaska Territorial Department of Mines Pamphlet 3-R, 26 p.

______1947, Mineral occurrences other than gold deposits in northwestern Alaska: Alaska Territorial Department of Mines Pamphlet 5-R, 48 p.

Arctic Environmental Information and Data Center (AEIDC), 1982, Mineral terranes of Alaska: University of Alaska, 6 plates, scale 1:1,000,000

Balen, M.D., 1990, Geochemical sampling results from Bureau of Mines investigations in the Valdez Creek Mining District, Alaska: U.S. Bureau of Mines Open-File Report 34-90, 218 p.

Barker, J.C., 1980, Occurrences and potential of lead and zinc mineralization in the Mt. Schwatka region, Alaska: U.S. Bureau of Mines Open-File Report 70-80, 51 p.

_____1981, Mineral Investigation in the Porcupine River drainage, Alaska: U.S. Bureau of Mines, Open-File Report 27-81, 189 p.

_____1986, Placer gold deposits of the Eagle Trough, upper Yukon River region, Alaska: U.S. Bureau of Mines Information Circular 9123, 23 p.

_____1988, Distribution of platinum-group metals in an ultramafic complex near Rainbow Mountain, east-central Alaska Range, in Vassiliou, A.H., Hausen, D.M., and Carson, D.J.T., eds., Process mineralogy vii: Applications to mineral beneficiation technology and mineral exploration, with special emphasis on disseminated carbonaceous gold ores: The Metallurgical Society, p.197-220.

Barker, J.C., and Lamal, K., 1988, Placer platinum-group metals offshore of the Goodnews Bay Ultramafic Complex: U.S. Bureau of Mines Open-File Report 53-88, 60 p.

Barker, J.C., Thomas, D.L., and Hawkins, D.B., 1985, Analysis of sampling variance from certain platinum and palladium deposits in Alaska: U.S. Bureau of Mines Report of Investigations 8948, 26 p.

Berg, H.C., and Cobb, E.H., 1967, Metalliferous lode deposits of Alaska: U.S. Geological Survey Bulletin 1246, 254 p.

Berryhill, R.V., 1963, Reconnaissance of beach sands, Bristol Bay, Alaska: U.S. Bureau of Mines Report of Investigations 6214, 48 p.

Beyer, B.J., 1980, Petrology and geochemistry of ophiolite fragments in a tectonic melange, Kodiak Island, Alaska: PhD. Dissertation, University California, Santa Cruz, 277 p.

Bird, M.L. and Clark, A.L., 1976, Microprobe study of olivine chromitites of the Goodnews Bay Ultramafic Complex, Alaska, and the occurrence of platinum: in U.S. Geological Survey Journal of Research, vol. 4, no. 6, p. 717-725.

Bjorklund, S., and Wright, W.S., 1948, Investigation of Knik Valley chromite deposits, Palmer, Alaska: U.S. Bureau of Mines Report of Investigations 4356, 5 p.

Bond, G.C., 1976, Geology of the Rainbow Mountain-Gulkana Glacier area, eastern Alaska Range, with emphasis on upper Paleozoic strata: Alaska Division of Geological and Geophysical Surveys Geologic Report 45, 47 p.

Brosge', W.P., and Reiser, H.N., 1968, Geochemical reconnaissance maps of granitic rocks, Collen and Table Mountain quadrangles, Alaska: U.S. Geological Survey Open-File Report 68-24, 4 sheets, scale 1:250,000.

Brooks, A.H., 1925, Alaska's mineral resources and production, 1923: U.S. Geological Survey Bulletin 773, p. 3-52.

Burand, W.M., and Saunders, R.H., 1966, A geochemical investigation of Mineral Creek, Rampart district: Alaska Division of Mines and Minerals Geochemical Report: U.S. Bureau of Mines Special Report for the U.S. Army Corps of Engineers, 101 p.

Bureau of Mines, 1963, Preliminary investigation of mineral resources of the Rampart Project, Alaska: U.S. Bureau of Mines Special Report for the U.S. Army Corps of Engineers, 101 p.

Burns, L.E., 1983, The Border Ranges ultramafic and mafic complex: Plutonic core of an intraoceanic island arc. PhD thesis, Stanford University, Stanford, CA, 2 sheets, scale 1:250,000

______1985, The Border Ranges ultramafic and mafic complex, south-central Alaska: cumulate fractionates of island arc volcanics: Canadian Journal of Earth Sciences, v. 22, p. 1020-1038.

Carlson, C.A., 1983, A statistical study of the geochemical evolution of the platinum-bearing magma from near Goodnews Bay, Alaska: Masters thesis, California State University, Hayward, 55 p.

Cathrall, J.B., Antweiller, J.C., and Mosier, E.L., 1987, Occurrence of platinum in gold samples from the Tolovana and Rampart Mining Districts, Livengood quadrangle, Alaska: U.S. Geological Survey Open-File Report 87-330, 12 p., 1 sheet, scale 1:250,000.

Chapin, Theodore, 1919, Platinum-bearing auriferous gravels of Chistochina River: U.S. Geological Survey Bulletin 692, p. 137-141.

Chapman, R.M., Weber, F.R., and Taber, Bond, 1971, Preliminary geologic map of the Livengood quadrangle, Alaska: U.S. Geologic Survey Open-File Report 71-66, 2 plates, scale 1:250,000.

Clark, A.L., and Hawley, C.C., 1968, Reconnaissance geology, mineral occurrences, and geochemical anomalies of the Yentna district, Alaska: U.S. Geological Survey Open-File Report, 64 p.

Clark, A.L., and Greenwood, W.R., 1972, Geochemistry and platinum-group metals in mafic to ultramafic complexes of southern and southeastern Alaska: U.S. Geological Survey Professional Paper 800-C, p. C157-160.

Clark, S.H.B., 1972, The Wolverine complex, a newly discovered ultramafic body in the western Chugach Mountains, Alaska: U.S. Geological Survey Open-File Report 72-70, 10 p.

Clark, S.H.B., and Foster, H.L., 1971, Geochemical and geological reconnaissance in the Seventymile river area, Alaska: U.S. Geological Survey Bulletin 1315, 21 p.

______1973, Basic data on the ultramafic rocks of the Eagle quadrangle, east-central Alaska: U.S. Geological Survey Open-File Report 73-140.

Clautice, K.H., 1978, Mineral deposits of the Kanuti River area: a summary report: U.S. Bureau of Mines Open-File Report 66-78, 15 p.

Cobb, E.H., 1973, Placer deposits of Alaska: U.S. Geological Survey, Bulletin 1374, 213 p.

______1975, Occurrences of platinum-group metals in Alaska: U.S. Geological Survey Map MR-64, 1 sheet, scale 1:2,500,000.

______1977, Summary of references to mineral occurrences (other than mineral fuels and construction materials) in the Tanana quadrangle: U.S. Geological Surveu Open-File Report 77-432, 110 p.

Crowe, D.E., Nelson, S.W., Brown, Philip, and Shanks, W.C., 1988, Stable isotope and fluid inclusion investigation of massive sulfide deposits, Orca and Valdez Groups, Alaska: Evidence for syngenetic sulfide deposition (abs.): Geological Society of America, Cordilleran Section, Abstracts with Programs, 1988, v. 20, no. 3, p. 153.

Csejtey, Bela, Jr., and Evarts, R.C., 1978, Serpentinite bodies in the Willow Creek district, southwestern Talkeetna Mountains, Alaska, in ***************, eds., The United States Geological Survey in Alaska - Accomplishments during 1978: U.S. Geological Survey circular 804-B, p. B92-B93.

Curtis, S.M., Ellersieck, Inyo, Mayfield, C.F., and Tailleur, I.L., 1984, Reconnaissance geologic map of southwestern Misheguk Mountain quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Map I-1502, scale 1:63,360.

Dahlin, D.C., Brown, L.L., and Kinney, J.J., 1983, Podiform chromite occurrences in the Caribou mountain and lower Kanuti River areas, central Alaska, Part II - Beneficiation: U.S. Bureau of Mines Information Circular 8916, 15 p.

Dahlin, D.C., Kirby, D.E., and Brown, L.L., 1985, Chromite deposits along the Border Ranges fault, southern Alaska, Part II - Beneficiation: U.S. Bureau of Mines Information Circular 8991, 37 p.

Degenhart, C.E., and others, 1978, WGM Consultants, Inc., Mineral studies of the western Brooks Range (contract J0155089): U.S. Bureau of Mines Open-File Report 103-78, 529 p.

Doyon, Ltd., 1986, Doyon Limited: Company report released to Bureau of Mines by Harry Noyes, unpaged.

Eberlein, G.D., Chapman, R.M., Foster, H.L., and Gassaway, J.S., 1977, Map and table describing known metalliferous and selected nonmetalliferous mineral deposits in central Alaska: U.S. Geological Survey Open-File Report 77-168-D, 132 p., 1 sheet, scale 1:1,000,000.

Ellersieck, Inyo, Curtis, S.M., Mayfield, C.F., and Tailleur, I.L., 1984, Reconnaissance geologic map of the South-central Misheguk Mountain quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Map I-1504, scale 1:63,360.

Enns, S., and Findlay, A., 1977, Venetie Indian Reservation: British Petroleum Mineral Survey, 54 p.

Fechner, S.A., 1988, Bureau of Mines mineral investigations in the Goodnews Bay Mining District: U.S. Bureau of Mines Open-File Report 1-88, 230 p.

Foley, J.Y., 1991, Platinum-group metals in the Valdez Creek Mining District: The Alaska Miner, v. 19, no. 1, p. 12-13.

Foley, J.Y., and Barker, J.C., 1985, Chromite deposits along the Border Ranges fault, alaska: Part I - Field investigations and descriptions of chromite deposits: U.S. Bureau of Mines Information Circular 8990, 57 p.

Foley, J.Y., Barker, J.C., and Brown, L.L., 1985, Critical and strategic minerals investigations in Alaska - Chromium: U.S. Bureau of Mines Open-File Report 97-85, 54 p.

______ 1986, Chromite resources in Alaska, in Daelenbach, C.C., ed., Chromium-chromite: Bureau of Mines assessment and research, proceedings of Bureau of Mines briefing held at Oregon State University, Corvallis, OR, June 4-5, 1985: U.S. Bureau of Mines Information Circular 9087, p. 23-29.

Foley, J.Y., Hinderman, Toni, Kirby, D.E., and Mardock, C.L., 1984, Chromite occurrences in the Kaiyuh Hills, west-central Alaska: U.S. Bureau of Mines Open-File Report 178-84, 20 p.

Foley, J.Y., and McDermott, M.M., 1983, Podiform chromite occurrences in the Caribou Mountain and lower Kanuti River areas, central Alaska, Part I - Reconnaissance investigations: U.S. Bureau of Mines Information Circular 8915, 27 p.

Foley, J.Y., Mardock, C.L., and Dahlin, D.C., 1988, Platinum-group metals in the Tonsina ultramafic complex, southern Alaska, in Vassiliou, A.H., Hausen, D.M., and Carson, D.J.T., eds., Process mineralogy vii: Applications to mineral beneficiation technology and mineral exploration, with special emphasis on disseminated carbonaceous gold ores: The Metallurgical Society, p. 165-195.

Foley, J.Y., Burns, L.E., Schneider, C.L., and Forbes, R.B., 1989, Preliminary report of platinum-group element occurrences in Alaska: Alaska Division of Geological and Geophysical Surveys Public-Data File 89-20, 32 p.

Foley, J.Y., and Summers, C.A., 1990, Source and bedrock distribution of gold and platinum-group metals in the Slate Creek area, northern Chistochina Mining District, east-central Alaska: U.S. Bureau of Mines Open-File Report 14-90, 49 p.

Foster, H.L., and Keith, T.E.C., 1974, Ultramafic rocks of the Eagle quadrangle, east-central Alaska: U.S. Geologic0al Survey Journal of Research, vol. 2, no.6, p. 657-669.

Foster, H.L., Albert, N.R.D., Griscom, A., Hessin, T.D., Menzie, W.D., Turner, D.L., and Wilson, F.H., 1979, The Alaskan mineral resource assessment program: Background information to accompany folio of geologic and mineral resources maps of the Big Delta quadrangle, Alaska: U.S. Geological Survey Circular 783, 19 p.

Foster, R.L., 1968a, Potential for lode deposits in the Livengood gold placer district, east-central Alaska: U.S. Geological Survey Circular 590, 18 p.

______1968b, Descriptions of the Ruth Creek, Lillian Creek, Griffin, Old Smokey, Sunshine No. 2, and Olive Creek lode prospects, Livengood district, Alaska: U.S. Geological Survey Open-File Report 68-104, 27 p.

______1969, Nickeliferous serpentinite near Beaver Creek, east-central Alaska: U.S. Geological Survey Circular 615, p. 2-4.

Foster, R.L., and Chapman, R.M., 1967, Locations and descriptions of lode prospects in the Livengood area, east-central Alaska: U.S. Geological Survey Open-File Report 67-91, 7 p.

Gates, G.O., 1942, Chromite deposits, Knik Valley, Alaska: U.S. Geological Survey unpublished report, 7 p.

Gault, H.R., Killeen, P.L., West, W.S., and others, 1953, Reconnaissance for radioactive deposits in the northeastern part of the Seward Peninsula, Alaska, 1945-47 and 1951: U.S. Geological Survey Circular 250, 31 p.

Gill, A.C., 1922, Chromite of Kenai Peninsula, Alaska: U.S. Geological Survey Bulletin 742, 52 p.

Goodfellow, Robert, Nelson, S.W., Bouse, R.M., and Koski, R.A., 1984, The Geologic setting and composition of a newly discovered manganese deposit on Hinchinbrook Island, Alaska: U.S. Geological Survey Open-File Report 84-671, 7 p.

Guild, P.W., 1942, Chromite deposits of Kenai Peninsula, Alaska: U.S. Geological Survey Bulletin 931-G, p. 139-176.

Hanson, L.G., 1963, Bedrock geology ofthe Rainbow Mountain area, Alaska Range, Alaska: Alaska Division of Mines and Minerals Geologic Report 2, 82 p.

Harrington, G.L., 1918, The Anvik-Andreafski region, Alaska (including the Marshall district): U.S. Geological Survey Bulletin 683, 70 p.

______1919a, The gold and platinum placers of Tolstoi district: U.S. Geological Survey, Bulletin 692, 339-351.

______1919b, The gold and platinum placers of the Kiwalik-Koyuk region: U.S. Geological Survey Bulletin 692, p. 369-400.

______1921, Mineral resources of the Goodnews Bay region: U.S. Geological Survey Bulletin 714, p. 207-228.

Harris, R.A., 1987, Structure and composition of sub-ophiolite metamorphic rocks, western Brooks Range ophiolite, Alaska (abs.): Geological Society of America, Cordilleran Section, Abstracts with Programs, v. 19, no. 6, p. 387.

_____1988, Origin, emplacement, and attenuation of the Misheguk Mountain Allochthon, western Brooks Range, Alaska (abs.): Geological Society of America, Annual Meeting, Abstracts with Programs, v. 20, no. 7, p. A112.

_____1989, The Brooks Range ophiolite and its analogues: Unpublished PhD Thesis, University College London, 520 p.

Hawley, C.C., Clark, A.L., Herdrick, M.A., and Clark, S.H.B., 1969, Results of geological and geochemical investigations in an area northwest of the Chulitna River, central Alaska Range: U.S. Geological Survey Circular 617, 19 p.

Hawley, C.C., and Clark, A.L., 1973, Geology and mineral deposits of the Chulitna-Yentna mineral belt, Alaska: U.S. Geological Survey Professional Paper 758-A, 10 p.

_____1974, Geology and mineral deposits of the upper Chulitna district, Alaska: US. Geological Survey Professional Paper, 758-B, 47 p.

Hawley, C.C., and Garcia, G., 1976, Mineral Appraisal and geologic background of the Venetie Native Lands: Bureau of Indian Affairs Contract Report No. 6E00-0102598.

Heide, H.E., Wright, W.S., and Rutledge, F.A., 1949, Investigations of the Kobuk River Asbestos deposits, Kobuk district, northwestern Alaska: U.S. Bureau of Mines Report of Investigations 4414, 25 p.

Herreid, G., 1969, Geology and geochemistry, Sithylemenkat Lake area, Bettles Quadrangle, Alaska: Alaska Division of Mines and Geology Geologic Report 35, 22 p.

_____1970, Geology of the Spirit Mountain nickel-copper prospect and surrounding area: Alaska Division of Mines and Geology Geologic Report 40, 19 p.

Hoare, J.M., and Coonrad, W.L., 1959, Geology of the Bethel quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geological Investigations Map I-285.

Hoffman, B., 1972, Geology of the Bernard Mountain area: M.S. Thesis, University of Alaska, Fairbanks, 68 p.

Humble Oil and Refining Company, 1959, Kemuk Mountain iron ore prospect, Dillingham district, Alaska: Humble Oil and Refining Company (unpublished company report), 20 p.

Jansons, Uldis, and Baggs, D.W., 1980, Mineral investigations of the Misheguk Mountain and Howard Pass quadrangles, National Petroleum Reserve, Alaska: U.S. Bureau of Mines Open-File Report 38-80, 76 p.

Jansons, Uldis, Hoekzema, R.B., Kurtak, J.M., and Fechner, S.A., 1984, Mineral occurrences in the Chugach National Forest, southcentral Alaska: U.S. Bureau of Mines Open-File Report 5-84, 223 p.

Jasper, M.N., 1967, Geochemical investigations along the Valdez to Chitina Highway in southcentral Alaska: Alaska Division of Mines and Minerals Geochemical Report 15.

Joesting, H.R., 1942, Strategic mineral occurrences in interior Alaska: Alaska Department Mines Pamphlet 1, 46 p.

Jones, D.L., Silberling, N.J., Csejtey, Bela, Jr., Nelson, W.H., and Blome, C.D., 1980, Age and structural significance of ophiolite and adjoining rocks in the upper Chulitna district, south-central Alaska: U.S. Geological Survey Professional Paper 1121-A, 21 p.

Keith, T.E.C., and Foster, H.L., 1973, Basic data on the ultramafic rocks of the Eagle quadrangle, east-central Alaska: U.S. Geological Survey Open-File Report 73-140, 4 sheets.

Keith, T.E.C., Page, N.J., Oscarson, R.L., and Foster, H.L., 1987, Platinum-group element concentrations in a biotite-rich clinopyroxenite suite, Eagle C-3 quadrangle, Alaska, in Hamilton, T.D., and Galloway, J.P., eds., Geologic Studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 62-66.

Killeen, P.L., and Mertie, J.B., Jr., 1951, Antimony ore in the Fairbanks district, Alaska: U.S. Geological Survey Open-File Report 51-46, 2 plates, scale 1:250,000, 44 p.

Kingston, J., and Miller, D.J., 1945, Nickel-copper prospect near Spirit Mountain, Copper River region, Alaska: U.S. Geological Survey Bulletin 943-C, p. 48-57.

Kurtak, J.M., 1982, A manganese occurrence on Chenega Island, Prince William Sound, Alaska: U.S. Bureau of Mines Open-File Report 124-82, 9 p.

Kurtak, J.M., Southworth, D.D., Balen, M.D., Fechner, S.A., and Clautice, K.H., 1991, U.S. Bureau of Mines mineral investigations in the Valdez Creek Mining District, south-central Alaska: The Alaska Miner, v. 19, no. 1, p. 15-19 and 23.

Loney, R.A, and Himmelberg, G.R., 1984, Preliminary report on ophiolites in the Yuki River and Mount Hurst areas, west-central Alaska, in Coonrad, W.L., and Elliott, R.L., eds. The United

States Geological Survey in Alaska: Accomplishments during 1981: U.S. Geological Survey Circular 868, p. 27-30.

______1985, Distribution and character of the peridotite-layered gabbro complex of the southeastern Yukon-Koyukuk ophiolite belt, in Bartsch-Winkler, Susan, and Reed, K.M., eds., The United States Geological Survey in Alaska: Accomplishments during 1983: U.S. Geological Survey Circular 945, p. 46-48.

______1988, Ultramafic rocks of the Livengood terrane: in Galloway, J.P., and Hamilton, T.D., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1987: U.S. Geological Survey Circular 1016, p. 68-70.

Maddren, A.G., 1919, The beach placers of the west coast of Kodiak Island: U.S. Geological Survey Bulletin 692, p.299-319.

Maloney, R.P., 1971, Investigations of gossans of Hot Springs Dome, near Manley Hot Springs, Alaska: U.S. Bureau of Mines Open-File Report 8-71, 28 p.

Martin, G.C., 1919, The Alaskan mining industry in 1917: U.S. Geological Survey Bulletin, 692, p.11-42.

Mayfield, C.F., Curtis, S.M., and Ellersieck, Inyo, 1983a, Reconnaissance geologic map of the De Long Mountains A3, B3, and parts of A4, and B4 quadrangles, Alaska: U.S. Geological Survey Open-File Report 83-183, scale 1:63,360, 2 sheets.

Mayfield, C.F., Tailleur, I.L., and Ellersieck, Inyo, 1983b, Stratigraphy, structure, and palinspastic synthesis of the western Brooks Range, northwestern Alaska: U.S. Geological Survey Open-File Report 83-779, 58 p., 5 plates.

Menzie, W.D., and Foster, H.L., 1978, Metalliferous and selected nonmetalliferous mineral resource potential in the Big Delta quadrangle, Alaska: U.S. Geological Survey Open-File Report 78-529-D, 61 p., 1 sheet, scale 1:250,000.

Mertie, J.B., Jr., 1919, Platinum-bearing placers of the Kahiltna Valley: U.S. Geological Survey Bulletin 692, p. 233-264.

______1934, Mineral deposits of the Rampart and Hot Springs districts, Alaska: U.S. Geological Survey Bulletin 844-D, p. 163-226.

______1940, The Goodnews platinum deposits: U.S. Geological Survey Bulletin 918, 1940, 97 p.

______1942, Tertiary deposits of the Eagle-Circle district, Alaska: U.S. Geological Survey Bulletin 917-D, p. 213-264.

______1969, Economic geology of the platinum minerals: U.S. Geological Survey Professional Paper 630, 130 p.

______1976, Platinum deposits in the Goodnews Bay District, Alaska: U.S. Geological Survey Professional Paper 938, 42 p.

Miller, T.P., 1970, Petrology of the plutonic rocks of west-central Alaska: U.S. Geological Survey Open-File Report 454, 130 p.

_____, 1972, Potassium-rich alkaline intrusive rocks of western Alaska: Geological society of America Bull., v. 83, p. 2111-2128.

Miller, T.P, and Elliott, R.L., 1969, Metalliferous deposits near Granite Mountain, eastern Seward Peninsula, Alaska: U.S. Geological Survey Circular 614, 19 p.

Moffit, F.H., 1944, Mining in the northern Copper River region, Alaska: U.S. Geological Survey Bulletin 943-B, p. 25-47.

_____1954, Geology of the eastern part of the Alaska Range: U.S. Geological Survey Bulletin 989-D, p. 63-218.

Mowatt, T.C., and Jansons, Uldis, 1985, Platinum and palladium in some mafic/ultramaficrocks from the Rabbit Creek area in the Noatak quadrangle, Alaska: U.S. Bureau of Mines Open-File Report 45-85, 23 p.

Mowatt, T.C., 1989, Platinum and Palladium in mafic-ultramafic igneous rocks, northwestern Alaska: geochemical petrological relationships, geological and mineral resource implications:____

____

Nelson, S.W., and Koski, R.A., 1987, The Midas Mine - A stratiform Fe-Cu-Zn-Pb sulfide deposit in Late Cretaceous turbidite near Valdez, Alaska (abs.): Geological Society of America Abstracts with Programs, v. 19, no. 6, p. 436.

Nelson, S.W., Miller, M.L., and Dumoulin, J.A., 1987, Resurrection Penninsula and Knight Island ophiolites and recent faulting on Montague Island, southern Alaska: Geological Society of America Centennial Field Guide - Cordilleran Section 1987, p. 433-438.

Nelson, S.W., and Nelson, W.H., 1982, Geology of the Siniktanneyak Mountain ophiolite, Howard Pass quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1441, scale 1:63,360.

Newberry, R.J., 1986, Mineral resources of the north-central Chugach Mountains, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigaitons 86-23, 44 p.

Overbeck, R.M., 1918, Placer mining in the Tolovana district, Alaska: U.S. Geological Survey Bulletin 712-F, p. 177-184.

Patton, W.W., Jr., and Miller, T.P., 1966, Regional geologic map of the Hughes quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map I 459, 1 sheet, scale 1:2,500,000.

______1970, Preliminary geologic investigations in the Kanuti River region, Alaska: U.S. Geological Survey Bulletin 1312-J, 7p.

Patton, W.W., Jr., Tailleur, I.L., Brosge', W.P., and Lanphere, M.A., 1977, Preliminary report on the ophiolites of northern and western Alaska, in Coleman, R.G., and Irwin, W.P., eds., North American ophiolites: Oregon Department of Geology and Mineral Industries Bulletin 95, p. 51-57.

Patton, W.W., Jr., Box, S.E., and Grybeck, Donald, 1989, Ophiolites and other mafic-ultramafic complexes in Alaska, U.S. Geological Survey Open-File Report 89-648, 27 p.

Pierce, H.C., 1946, Exploration of Spirit Mountain nickel prospect, Canyon Creek, lower Copper River region, Alaska: U.S. Bureau of Mines Report of Investigations 3913, 3 p.

Pittman, T.L., 1957, Bureau of Mines examination report on Tonsina chromite, Tonsina, Alaska: U.S. Bureau of Mines, Juneau, Alaska, 12 p.

Reed, B.L., and Eberlein, D.G., 1972, Massive sulfide deposits near Shellabarger Pass, southern Alaska Range, Alaska: U.S. Geological Survey Bulletin 1342, 45 p.

Reed, B.L., and Nelson, S.W., 1980, Geologic map of the Talkeetna quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Map I-1174, 15 p., 1 sheet, scale 1:250,000.

Reed, B.L., Nelson, S.W., Curtain, G.C., and Singer, D.A., 1978, Mineral Resources map of the Talkeetna quadrangle, Alaska: U.S. Geolgical Survey Miscellaneous Field Studies Map MF 870-D, scale 1:250,000.

Richter, D.H., 1967, Geology of the upper Slana-Mentasta Pass area, southcentral Alaska: Alaska Division of Mines and Minerals Geologic Report 30, 25 p.

Richter, D.H., Albert, N.R.D., Barnes, D.F., Griscom, A., Marsh, S.P., and Singer, D.A., 1975, The Alaska Mineral Resource Assessment Program: Background information to accompany folio of geologic and mineral resource maps of the Nabesna quadrangle, Alaska: U.S. Geological Survey Circular 718, 16 p.

Richter, D.H., Singer, D.A., and Cox, D.P., 1975, Mineral resources map of the Nabesna quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-655K, scale 1:2,500,000.

Roberts, W.S., 1984a, Bulk mineralogy and geochemistry of selected Alaskan chromium spinel deposits: U.S. Bureau of Mines Information Circular 9023, 13 p.

______1984b, Economic potential for chromium, platinum, and palladium in the Mount Hurst ultramafics, west-central Alaska: U.S. Bureau of Mines Open-File Report 84-22, 52 p.

Robinson, G.D., Wedow, Helmuth, Jr., and Lyons, J.B., 1955, Radioactivity investigations in the Cache Creek area, Yentna district, Alaska, 1945: U.S. Geological Survey Bulletin 1024-A, p. 1-23.

Roeder, Dietrich, and Mull, C.G., 1978, Tectonics of Brooks Range ophiolites (Alaska): American Association of Petroleum Geologists Bull., v. 62, no. 9, p. 1696-1702.

Rose, A.W., 1965, Geology of and mineral deposits of the Rainy Creek area, Mt. Hayes quadrangle, Alaska: Alaska Division of Mines and Minerals, Geologic Report 14, 49 p.

______1966a, Geological and geochemical investigations in the Eureka Creek and Rainy Creek areas, Mt. Hayes quadrangle, Alaska: Alaska Division of Mines and Minerals Geologic Report 20, 37 p.

______1966b, Geology of chromite-bearing ultramafic rocks near Eklutna, Anchorage quadrangle, Alaska: Alaska Division of Mines and Minerals Geologic Report 18, 20 p.

______1967, Geology of the upper Chistochina River area, Mt. Hayes quadrangle, Alaska: Alaska Division of Mines and Minerals Geologic Report 28, 39 p.

Rosenblum, S., Overstreet, W.C., and Carlson, R.R., 1982, Placer deposits in the Goodnews Bay District, Alaska: *in* Geological Survey Research, 1981. U.S. Geological Survey Professional Paper 1275, 1982

Rosenblum, S., Carlson, R.R., Nishi, J.M., and Overstreet, W.C., 1986, Platinum-group elements in magnetic concentrates from the Goodnews Bay District, Alaska: U.S. Geological Survey Bulletin 1660, 38 p.

Rutledge, F.A., 1946, Exploration of Red Mountain chromite deposits, Kenai Peninsula, Alaska: U.S. Bureau of Mines Report of Investigations 3885, 26 p.

Sainsbury, C.L., Kachadoorian, Reuben, Hudson, Travis, Smith, T.E., Richards, T.R., and Todd, W.E., 1969, Reconnaissance geologic maps and sample data, Teller A-1, A-2, A-3, B-1, B-2, B-3, C-1, and Bendeleben A-6, B-6, C-6, D-5, D-6 quadrangles, Seward Peninsula, Alaska: U.S. Geological Survey Open-File Report, 49 p.

Sanford, R.S., and Cole, J.W., 1949, Investigations of Claim Point chromite deposits, Kenai Peninsula, Alaska: U.S. Bureau of Mines Report of Investigations 4419, 11 p.

Saunders, 1955, Report on the examination of the Sours chromium prospect, Noatak quadrangle: Territory of Alaska, Department of Mines, Prospect Examination 26-1, 3 p.

_____1967, Mineral occurrences of the Yukon-Tanana region, Alaska: Alaska Division of Mines and Minerals, 60 p.

Smith, P.S., 1930, Mineral industry of Alaska in 1927: U.S. Geological Survey Bulletin 810, p. 1-64.

Southworth, D.D., 1984a, Columbium in the gold- and tin-bearing placer deposits near Tofty, Alaska: U.S. Bureau of Mines Open-File Report 174-84, 25 p.

______1984b, Geologic and geochemical investigation of the "Nail" Allochthon, east-central Alaska: U.S. Bureau of Mines Open-File Report 176-84, 19 p.

______1984c, Red Mountain: a southeastern Alaska-type ultramafic complex in southwestern Alaska: Geological Society of America Abstracts with Programs v. 16, no. 5, p. 334.

______1985, Geologic and geochemical investigation of the "Nail" Allochthon, east-central Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 85-38, 19 p.

______1986, Geology of the Goodnews Bay Ultramafic Complex: M.S. thesis, University of Alaska, Fairbanks, 114 p.

Southworth, D.D., and Foley, J.Y., 1986, Lode Platinum-group metal potential of the Goodnews Bay Ultramafic Complex, Alaska: U.S. Bureau of Mines Open-File Report 51-86, 82 p.

Stout, J.H., 1976, Geology of the Eureka Creek Area, east-central Alaska Range: Alaska Division of Geological and Geophysical Surveys Geologic Report 46, 32 p.

Thomas, B.I., 1957, Tin-bearing placer deposits near Tofty, Hot Springs district, central Alaska: U.S. Bureau of Mines Report of Investigations 5373, 56 p.

______1965, Reconnaissance sampling of the Avnet manganese prospect, Tanana quadrangle. central Alaska: U.S. Bureau of Mines Open-File Report 10-65, 8 p.

Thorne, R.L., and Wright, W.S., 1948, Sampling methods and results at the Sullivan Creek tin placer deposits, Manley Hot Springs, Tofty, Alaska: U.S. Bureau of Mines Report of Investigations 4346, 8 p.

Ulrich, S.D., 1984, Formation of a platinum-rich beach placer deposit, Goodnews Bay, Alaska: M.A. thesis, University of Texas, Austin, 179 p.

Warner, J.D., 1985, Critical and strategic minerals in Alaska: tin, tantalum, and columbium: U.S. Bureau of Mines Information Circular 9037, 19 p.

Warner, J.D., Mardock, C.L., and Dahlin, D.C., 1986, A columbium-bearing regolith on upper Idaho Gulch, near Tofty, Alaska: U.S. Bureau of Mines Information Circular 9105, 29 p.

Waters, A.E., 1934, Placer concentrates of the Rampart and Hot Springs districts, Alaska: U.S. geological Survey Bulletin 844-D, p. 227-246.

Wayland, R.G., 1961, Tofty tin belt, Manley Hot Springs district, Alaska: U.S. Geological Survey Bulletin 1058-I, p. 363-414.

Weber, F.R., Foster, H.L., Keith, T.E.C., and Dusel-Bacon, Cynthia, 1978, Preliminary geologic map of the Big Delta quadrangle, Alaska: U.S. Geological Survey Open-File Report 78-529-A, scale 1:250,000.

Wedow, Helmuth, Jr., 1954, Reconnaissance for radioactive deposits in the Eagle-Nation area, east-central Alaska, 1948: U.S. Geological Survey Circular 316, 9 p.

Wedow, Helmut, Jr., White, M.G., and Moxham, R.M., 1952, Interim report on an appraisal of the uranium possibilities of Alaska: U.S. Geological Survey Open-File Report 51, 123p.

Wells, 1957, Bureau of Mines mineral dressing report on gravity beneficiation of Tonsina chromite ore: U.S. Bureau of Mines, Juneau, Alaska, 9 p.

Wells, R.R., Sterling, F.T., Erspamer, E.G., and Stickney, W.A., 1957, Laboratory concentration of chromite ores, Red Mountain district, Kenai Peninsula, Alaska: U.S. Bureau of Mines Report of Investigations 5377, 22 p.

West, W.S., 1954, Reconnaissance for radioactive deposits in the lower Yukon-Kuskokwim region, Alaska, 1952: U.S. Geological Survey Circular 328, 10 p.

Zelenka, B.R., 1988, A review of favorable offshore and coastal depositional sites for platinum-group metals in the Goodnews Bay Mining District, Alaska: U.S. Bureau of Mines open-file report 11-88, 25 p.